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A model for evaluating differentiating characteristics of the Colo soils as mapped in the North Central Region

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A MODEL FOR EVALUATING DIFFERENTIATING CHARACTERISTICS OF THE COLO SOILS AS MAPPED IN THE NORTH CENTRAL REGION

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A model for evaluating differentiating characteristics of the Colo soils as mapped in the North Central Region

by

Mary Elizabeth Collins

A Dissertation Submitted to the

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TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

Page

INTRODUCTION

The Colo soil series, presently classified as fine-silty, mixed, mesic Cumulic Haplaquoll, is formed in alluvial sediments and is mapped on floodplains and upland drainageways. Its geographic range is from eastern Nebraska to eastern Illinois and from southern Minnesota to northern Missouri (Figure 1). Within this broad geographic area there are variations in (1) climate, (2) vegetation, (3) parent material, (4) relief, and (5) time--the five independent variables that define the soil system (Jenny, 1941). According to Jenny (1941), for a given combination of climate, vegetation, parent material, relief, and time, the state of the soil system is fixed; only one soil exists under these conditions. The Colo soil exists under different combinations of the five soil forming factors.

Jenny's (1941) equation:

$$s = f(cl,o,r,p,t...)$$

where s denotes any soil property, f is a function of, cl is climate, o is organisms (vegetation, biotic influence), r is topography, also including certain hydrologic features (e.g., water table), p is parent material, defined as state of soil at soil formation at time zero, t is age of soil, absolute period of soil formation and ... additional, unspecified factors. The additional unspecified factors may have a more pronounced effect of the development of this and other soils derived from alluvial sediments.

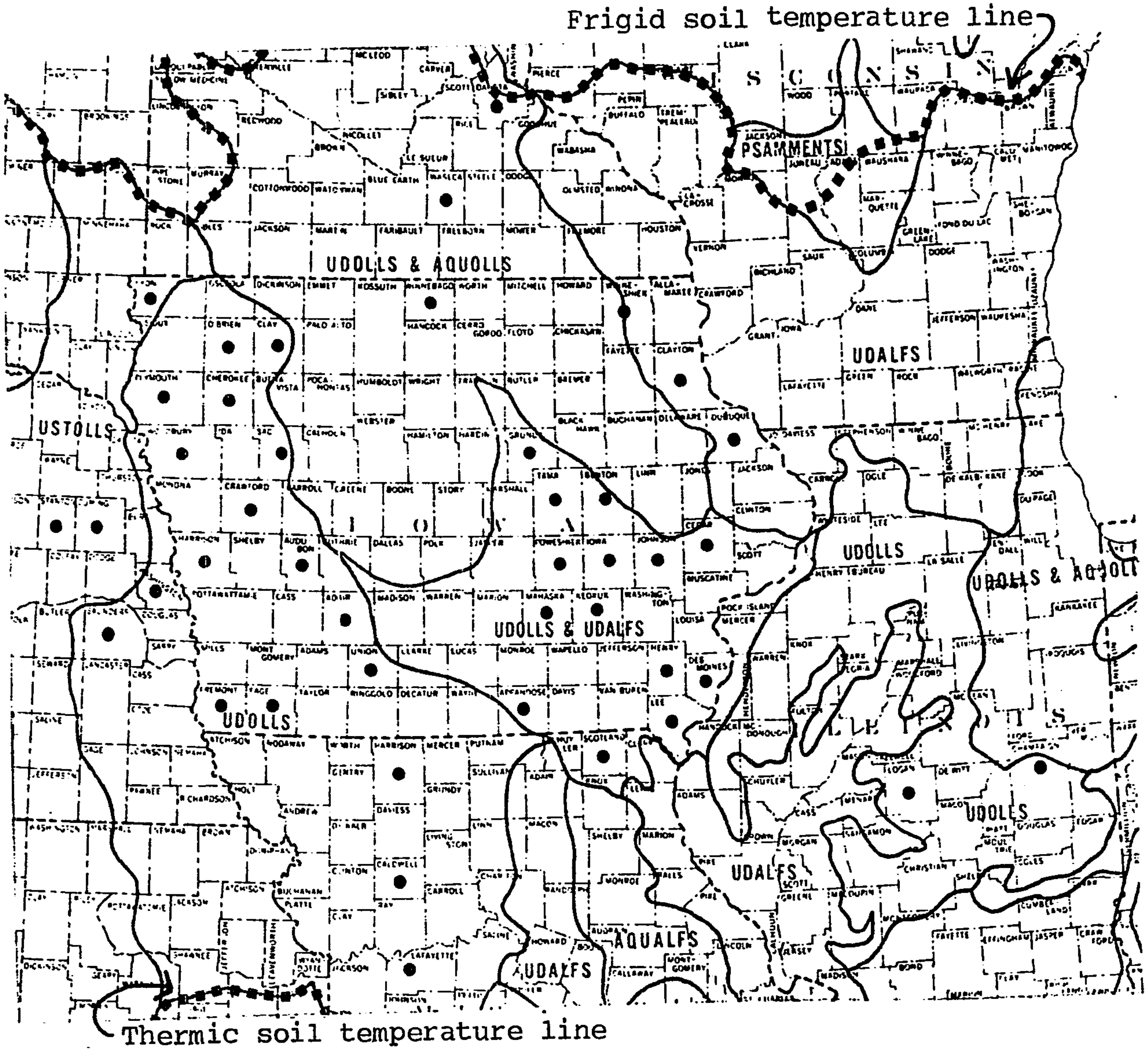


Figure 1. Location of sites sampled

A limited amount of research has been done involving soils derived from alluvial sediments. Some soils in individual watersheds have been studied but few soils have been studied on a regional scale. This investigation will study one soil series throughout its mapped geographic region.

The objectives of this study are to:

1. Study and characterize the Colo soil series as mapped in the North Central Region (NCR).
2. Determine and compare soil and landscape parameters relative to the Colo soil series in the NCR.
3. Develop a model to enable a better understanding of the genesis of soils derived in alluvial sediments in the NCR.
4. Discuss classification of the Colo soils.

BACKGROUND

Model of a Soil System

The natural soil system is very complex, and therefore, difficult to describe in its entirety. Models or working hypotheses are used to help understand soil developmental processes within some realm of probability. Most soil forming and soil behavioral processes are extremely complicated with many physical, chemical, and biological processes involved. Seldom is sufficient basic knowledge available to describe a total soil system with absolute certainty, indicating all factors involved. As more and more soil processes are described, models become more useful to better explain the relationships between data and the real soil system. The role of models is to build convenient devices for collecting, describing, explaining,and predicting data (Dijkerman, 1974).

Models are either concrete (physical objects) or conceptual (abstract concepts). Concrete models are not used extensively as compared to conceptual models in soil morphology and genesis studies. Examples are soil samples or typical pedons used to represent real soil systems which are too large to be investigated in their entirety. Conceptual models begin as ideas created in the human mind. Mental, structural, verbal, and mathematical models are considered to be conceptual models. Mental models are images in the human mind; ideas about the real soil system. These ideas are not recorded.

Mental models may easily be forgotten. Therefore, it is best to record ideas as a verbal, structural, or mathematical model. An example of a mental model is the image a field soil scientist has about the area in which he is working. Unconsciously, the field soil scientist has developed a model of soils and landscapes. Usually, this information is recorded as a structural model--a soil map.

Structural models indicate the structure or behavior of a system in the form of a simple drawing, diagram, or map. These models require some simplifying of concept and scale. Soil as a dynamic system may also be shown as a structural model by flow diagrams or sequential models as used by Arnold (1965) to explain the evolution of a particular soil.

Verbal models are mental concepts expressed in words. Well-known pedological ideas such as the factors of soil formation (Jenny, 1941) and the concept which describes soil genesis as two overlapping processes--the accumulation of parent materials and differentiation of horizons in the profile by additions, removals, transfers, and transformations (Simonson, 1959)--are examples of verbal models. Another example of a verbal model is the energy model by Runge (1973) which states that soil development is a function of leaching water and organic matter production.

Portions of Jenny's soil forming equation have been expressed as a mathematical model (Jenny, 1961). In mathematical models, the structure and behavior of a system are expressed quantitatively as mathematical equations.

Even though mathematical models have been used previously in soil chemistry and soil physics, Jenny (1961) did express the soil's changing ecosystem as fluxes or the transport of matter and energy along gradient or potential differences. In soil morphology and genesis, as well as in other areas of soil science, advanced statistical models are being used in soil research. Statistical models are very important to test hypotheses against the real soil system (Dijkerman, 1974).

The function of models may be observational (to collect data from natural soil systems that are too large to be studied in their entirety), experimental (to collect data by stimulating soil processes under artificially controlled conditions), descriptive (to characterize the system), explanatory (to understand the relationship and behavior under study), and predictive (to forecast the relationships and behavior under study).

Observational models are used in pedology to collect data which will represent the entire soil system. These "samples" are then brought to the laboratory for analysis. Experimental models may oversimplify the process being studied. Caution must be taken because laboratory conditions and results may be different from those in the field. Examples of descriptive models are the Munsell notation, which is a descriptive model of soil color, and the soil map which describes the soils' occurrence on the landscape.

Explanatory models such as the stability diagrams of minerals in various soil environments are based on the theory of thermodynamics. The five factors of soil formation were known originally as an explanatory model which explained the differences among soils at the landscape level. Presently, the five factor equation is considered to be a descriptive model. All explanatory models are also predictive models; in fact, the validity of explanatory models can only be tested by using these as predictive models.

The future is not entirely unpredictable but nothing in the future can be predicted perfectly. In science, the assumption is that everything in the universe is related, however remotely, and therefore, predictable. What is hoped for are descriptions of what may occur with adequate accuracy for useful purposes.

Jenny's general state equation

Soil is a physical, dynamic, open system. The soil system may have substances added or removed from its boundaries. A system is the part of the universe in which we are particularly interested (Atkins, 1978). Every system is identified by properties which are distinguished by symbols. A system is defined when its properties are stated. A general equation describing a system is $F(s_1, s_2, s_3, s_4, \ldots) = 0$, where F is a function of, and s_1, s_2, s_3, and s_4 are properties of the system. Because this equation is an exact differential, the properties of this system are functionally related. Changing one property an infinitesimal amount, theoretically, changes the other properties. Therefore, the system has been changed.

This equation describes many natural systems. However, it is too general to describe the soil system. Jenny (1941) realized that the soil system could be distinguished from other natural systems by assigning certain limits to the properties s_1, s_2, etc. For example, in this way soil could be defined as having 95% or less water or else the system would be called a swamp, lake etc. (Jenny, 1941).

A system may undergo change and assume a different state when one or more of its properties changes. Various states of the soil system are known as soil series in the United States (approximately 10,000) (Soil Survey Staff, 1975b).

Simonson's theory of soil genesis

Soil development usually does not begin until the accumulation of parent material ceases. The relationship between soil development, parent material and soil can be expressed as:

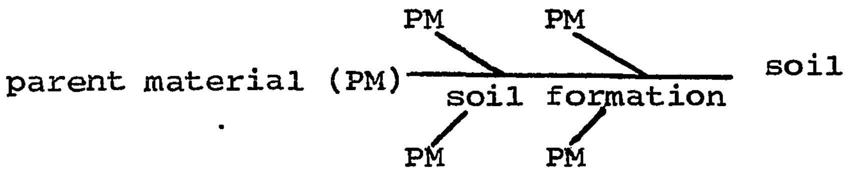
$$\text{parent material} \xrightarrow[\text{soil formation}]{} \text{soil} \quad .$$

During soil formation another variable, time, must be considered. The soil system is not static but dynamic, changing with time. The soil system changes its properties in a direction towards an equilibrium state with its environment. Since soil properties change very slowly, it is very difficult to know when a soil has reached a final equilibrium. A final equilibrium is defined by Jenny (1941) as complete transformation of rock into a "mature soil".

Determining the final stage of soil development or final equilibrium is extremely difficult. Simonson (1959) believed soil genesis consisted of two steps: (a) the accumulation of parent material, and (b) the differentiation of horizons in the profile. These steps are not distinct but merge and overlap so that it is impossible to tell where one begins and the other ends. Therefore, it would be difficult to determine if the soil is in dynamic equilibrium with its environment. Simonson's interpretation of soil genesis is that it is the combination of processes in the soil which determines horizon differentiation. After accumulation of parent materials, processes such as additions, removals, transfers, and transformations operate. It is the balance among these processes in a given combination that becomes the key to the nature of a soil.

Thus, the theory of soil genesis is outlined by placing primary emphasis on the operation of any combination of processes on horizon differentiation. Also, it is the shift in balances among combinations of processes that is responsible for soil differences rather than the operation of different genetic processes. Simonson's theory can explain the existence of both local and regional differences among soils.

The genesis of soils derived in alluvial sediments may be better understood by applying some of Jenny's and Simonson's ideas related to the development of soils. Jenny's definition of parent material as the initial state of the soil system is similar to Simonson's first step in soil genesis, the accumulation of parent materials. Both models work well with upland soils that have had parent material deposited, e.g., loess, glacial till, and deposition has ceased. Soils formed in alluvial sediments generally do not have an end point for the accumulation of parent material. Sedimentation takes place every time the river or stream floods. Therefore, Jenny's diagram for alluvial soils should be:



The accumulation of parent material during soil formation is a continuing process. As long as the stream floods depositing fresh sediment, the soil surface will continue to accumulate parent material. The rate of deposition may have a direct influence on the rate of development. In theory, horizon differentiation should begin after sedimentation ceases.

Simonson (1959) realized that soil development is a continuing process and the accumulation of parent materials and horizon differentiation may proceed simultaneously in all soils. Thus, it is the rate of parent material accumulation and the degree of differentiation which governs the genesis of the soil.

Arnold's multiple working hypothesis

A multiple working hypothesis in soil genesis was described by Arnold (1965) to explain some observed soil features using sequential models depicting alternate modes of development. Arnold (1965) stated, "Current theories of soil genesis emphasize variable rates of processes in the differentiation of soils, and include the implication that soils of similar morphology may have travelled different pathways." In such cases, the soil may be polygenetic. The soil's morphology is related to different environmental conditions and the consequence of a combination of variable rate genetic processes.

More knowledge is needed about the interactions produced by changing environments. Explaining or interpreting observed soil features is becoming increasingly difficult as more information becomes available. The purpose of any concept in soil genesis is to better explain the processes involved in observed soil properties. Ruhe and Scholtes (1956) asked, "Is the concept of relating soil characteristics only to observable environments justifiable in view of the complexity of the decipherable histories of the soil landscapes?"

Use of multiple working hypotheses permits an individual to study and analyze at one time several possible explanations of a phenomenon. Hypotheses are tentatively accepted to explain certain observed and measured factual relationships.

Arnold (1965) proposed four alternative pathways or sequential models to describe the result of changes in a soil system. He used progressive steps in a sequence of events to explain the possible direction of soil genesis. In developing his multiple working hypotheses through sequential models, Arnold had to rationalize the development of some observable soil properties by soil-soil factor relationships. Age determinations or the time factor in soil development cannot be duplicated in the laboratory. Therefore, soil-soil factor relationships, such as determining the age of the organic matter in the surface horizon or a relative time-scale for landscape evolution, could provide reasonable estimates of rates of soil forming processes.

In Arnold's four sequential models, the soil's development proceeds in a stepwise manner explaining the initial state of the soil system to the formation of Tama-like or Protivin soils in Iowa. Each step shows the soil properties which have changed mainly as a result of the environment. Examples are a gradual change from forest to prairie vegetation, an unstable phase of a geomorphic cycle, or an accumulation of transported sediments.

Cline's (1961) statement indicates the applicability of multiple working hypotheses in soil genesis:

> With changes of the soil itself, or of the environment... one may expect the rates of such processes to change relative one to another, and as a consequence, the course of soil development may be expected to shift in time to produce new sets of properties we recognize as differences in kind rather than degree.

Runge's energy models

In a slowly changing system under continuous development, the cause and effect relationship is difficult to separate. Runge (1973) described a model of soil development based on energy vectors of water movement through the soil profile and organic matter production, realizing some vectors are more important in controlling soil development than others.

The energy source for Runge's models is gravitional energy which is available when water infiltrates and percolates to lower depths in the soil profile or runs off the soil surface. The amount of gravitational energy which runs off the soil surface is lost energy at least for soil development in that area. Gravitational energy which enters the soil contributes to the development of the soil profile, e.g., horizon differentiation.

The relative amounts of energy, the internal and external fluxes, through time, probably have affected landscape evolution and soil profile evolution. Stable landscapes and developed profiles with distinct horizon differentiation are probably in a lower energy state than less stable landscapes and less developed profiles.

The concept of entropy, which is a measure of randomness or disorder, is considered an important component of the second law of thermodynamics. Statistically speaking, entropy is the direction of spontaneous change from a state of low probability of occurring to one of maximum probability (Leopold and Langbein, 1962).

Runge (1973) applied the concept of entropy to soil profiles to explain how loess soil parent material is at maximum disorder or has no profile development (high entropy) while a well-developed soil is more ordered than it was initially. Simonson (1959) did not mention entropy but his theory on soil genesis did involve the concept of each soil having a maximum probability of developing into a unique soil. The maximum probability would be the result of the balances among the combination of chemical, physical, and biological processes occurring in the soil.

Entropy in Landscape Evolution

The distribution of energy in a stream system just as in a soil system tends towards the most probable state allowed by the environment. Landscape evolution begins immediately after the first drop of water falls as precipitation on an uplifted land mass. The water modifies the landscape by creating a path for succeeding drops of water. It modifies the landscape by reducing the land mass and carrying with it particles of the land in solution and sediment. The different paths taken through time mold a drainage network on the land surface. How well-developed the drainage network is will be expressed by the relative differences in local topography.

The concept of entropy is applicable to a stream system (drainage network) in that the most probable condition exists when energy in a stream system is uniformly distributed as is permitted by the local surroundings (Leopold and Langbein, 1962). The most probable conditions are similar to Hack's (1960) concept of dynamic equilibrium. The concept of dynamic equilibrium explains how every slope and every channel in an erosional system is adjusted to every other slope and channel. In other words, the landscapes and the processes forming them are considered part of an open system in a steady state of balance. When topography is in equilibrium and erosional energy remains constant, elements of topography are downwasting at the same rate. However, if erosional energy changes in space as well as time, the landscape will also change.

The development of the landscape involves the distribution of the total available energy in the stream system. For example, in the stream system the water which moves down the channel loses potential energy and kinetic energy. Heat is also lost along the channel margins.

In approaching the evolution of landscapes with thermodynamic concepts, an attempt is made to gain some additional insight into the distribution of energy and the modifications of landforms in space and time. The concepts of entropy and dynamic equilibrium in landscape evolution are important theories in determining the genetic pathway of all soils.

History of the Colo Soil Series

The Colo soil series was established in Polk County, Iowa, in 1951. The type location was in the southeast corner of the NE¼ of the SE¼ of sec. 37, T81N, R22W (Soil Survey Staff, 1951a). At that time, members of the Colo series were classified as dark colored Humic Gley soils developed in heavy textured sediments in the floodplains of streams draining out of the areas of late Wisconsin till. Soils of the Colo series were not as heavy textured and slowly permeable as soils of the Wabash series. Comfrey soils were similar except they were calcareous within the solum.

The Colo soil series was described in 1951 as having a black silty clay loam A horizon to a depth of 61 cm. The B horizon was very dark gray to black, silty clay loam. Reaction was neutral. Ranges in characteristic allowed textures of silty clay loams or clay loams. Distribution of the series was unknown in 1951.

In 1953, the Colo soil series was classified as Humic Gley soils intergrading to Alluvial soils. The series was described in 1953 as dark colored, poorly drained, moderately fine textured, alluvial soil developing on floodplains and low terraces in moderately fine-textured, neutral to mildly alkaline alluvium (Soil Survey Staff, 1953). The alluvial sediment was derived principally from Wisconsin loess and glacial drift. These soils had been included in the Sawmill series, therefore, were very similar except that the Colo soil series had darker colors above 122 cm. The Colo soil series was similar to the Huntsville soil series except the Huntsville series was medium-textured rather than moderately fine-textured. Also, the Wabash soil series was similar except for finer textured profiles and very little evidence of gleying above 122 cm.

The Colo soil series was described in 1953 as having a black, silty clay loam and clay loam A horizons to 36 cm. The C horizons extended from 36 to 152+ cm and was a very dark-gray, clay loam with some stratified lenses of silt loam and loam. Reaction was slightly acid throughout. Ranges in characteristics were in color (10YR and 2.5Y hue, values of 2 to 4 and chromas of 1 predominate in the upper 122 cm) and the degree of stratification below 91 cm. At that time, the distribution of the series was thought to be principally in north-central and western Iowa and possibly in southern Minnesota.

The type location was moved to Monona County, Iowa, in the late 1950s. The type location was 219 meters south and 39 meters east of the NW corner of the NW¼, NE¼, sec. 27, T82N, R42W (Soil Survey Staff, 1975a). It was classified according to Soil Taxonomy (Soil Survey Staff, 1975b) as fine-silty, mixed, mesic Cumulic Haplaquoll. The Colo soil series was defined as having very thick, black, silty clay loam A horizons, very dark gray, firm, silty clay loam AC horizons and mottled very dark gray and dark gray silty clay loam Cg horizons at depths below 91 cm. A difference between the Monona County Colo series and profiles discussed earlier was the thickness of the black and very dark gray colors. This soil must have a mollic epipedon, as defined at that time, 91 cm or more thick and a clay content which averaged less than 35% clay within 25 to 100 cm.

The Colo series was mapped on nearly level to very gently sloping floodplains, low benches, and gently sloping upland drainageways near the water course and formed from noncalcareous silty sediments containing less than 20% sand of which one-half or less is fine and medium in size (Soil Survey Staff, 1975a). Soils of the Colo series were poorly drained, even though determining the drainage class was difficult because of the thick mollic epipedon and depth to a gleyed C horizon.

The type location in Monona County was not satisfactory to the Iowa Soil Survey Staff. Therefore, for a brief time in 1974, the type location was moved to Sac County, Iowa. The site in Sac County averaged 36% clay between 25 and 100 cm. It was rejected as a suitable site by the Midwest Technical Service Correlation Staff (Robert Turner, USDA Soil Conservation Service, Midwest Technical Service Center, Lincoln, Nebraska, Colo soil series file).

Presently, the type location for the Colo soil series is in Audubon County, Iowa (about 2 miles south of Exira; 393 meters south and 108 meters east of the center of sec. 8, T78N, R35W) (Soil Survey Staff, 1978). In contrast to the profile in Monona County, the Audubon County profile has an A-B-C horizonation. The location was moved to Audubon County primarily because the site in Monona County was not within an area mapped as Colo. Even though the site location has only been in Audubon County since 1978, it is likely that the type location will be moved to another site.

Principal competing soil series

When new areas are soil surveyed, new soil series may be recognized. Remapping of previously surveyed areas sometimes results in refinements of an existing series by "splitting" or establishing a new series. As discussed earlier, theoretically, there are an infinite number of soil series. Soil scientists restrict a soil series by limiting its properties in defining the soil's range in characteristics.

The Colo soil series was established by subdividing the Sawmill series. One distinguishing characteristic of the Colo series is a mollic epipedon greater than 91 cm thick. The Sawmill series has a mollic epipedon less than 91 cm thick. Otherwise, the two series are very similar in morphology.

The Zook, Calco, and Coland were established by redefining the Colo series. Zook soils have more clay (>35%) in the 25 to 100 cm control section. Calco soils are calcareous. Coland soils have more than 15% fine sand or coarser in the control section. These series and the Sawmill series are called principal competing series.

Problems with the Colo soil series

In 1965, the concept of Colo was a soil with a mollic epipedon as defined at that time to be greater than 102 cm while the Sawmill series had a mollic epipedon between 51 to 102 cm thick (J. Kenneth Ableiter, USDA Soil Conservation Service, Lincoln, Nebraska, Colo soil series file). The idea of separating these soil series by the thickness of the mollic epipedon concerned some soil scientists. They did not believe the series could be mapped consistently. Simonson reported in 1961,

> I should think it would be well to plan to assemble and examine profile descriptions to represent each of these series so as to see whether or not they could be set apart.... After enough profile descriptions have been accumulated to establish norms and ranges for the two series, those descriptions would have to be studied and proposals developed for differentiating two series or for dispensing with one of them. I should think that the Colo series would be the first candidate for the inactive list, if one or the other of these two were dropped from active use (Roy Simonson, USDA Soil Conservation Service, Lincoln, Nebraska, Colo soil series files).

In 1965, it was reported Iowa and Illinois agreed that two series are needed for the soils that have been included in the Sawmill and Colo series. Therefore, Iowa would continue to map Colo and Illinois would map Sawmill. A year later, the thicknesses of the mollic epipedon was changed to greater than 91 cm thick and less than 91 cm thick for the Colo and Sawmill soils, respectively.

The existence of a B horizon in the Colo soil profile has also been discussed. The official profile description in 1951 (Soil Survey Staff, 1951a) had an A-B horizon sequence to 107 cm. Later profile descriptions had A-C profiles. In 1965, Colo was allowed to have a B horizon and it was reported that it usually did have a B horizon. There was some question as to the kind of a B horizon. Designating horizons on dark colored soils is difficult. Some soil scientists believed Colo soils had a weak structural B horizon which would not qualify as a diagnostic horizon. In horizons with prismatic breaking to moderate fine subangular or angular blocky structure, these should be called B1, B2, and B3 horizons in Colo profiles. The present typifying pedon has a structural B horizon.

Recently, soil scientists in Nebraska have correlated Colo soils with a water table between .6 to 1.2 meters below the soil surface. They have used the term somewhat poorly drained for soils with properties such as those in Colo soils. The water table for the Colo soils in Iowa is reported to be between .3 to 1 meter below the surface from from February to November (Soil Survey Staff, 1978). Therefore, the term poorly drained has been used to describe the shallow depth of the water table. Nebraska would like the drainage terminology to be changed to poorly and somewhat poorly drained (L. E. Mitchell, USDA Soil Conservation Service, Lincoln, Nebraska, Colo soil series file). This problem has not yet been resolved.

Climatic and Vegetative Influence on the Development of Iowa Soils

Climatic influence

Iowa is located in the north temperate zone and has a midcontinental subhumid climate characterized by hot summers with moderate precipitation and cold, dry winters (Simonson et al., 1952).

Annual precipitation in the state ranges from 64 cm in the extreme northwest corner of the state to 89 cm in the southeast corner. Much of Iowa's annual precipitation comes from rainfall of short duration, even though official records have shown rainfall amounts in a 24-hr period of more than 43 cm. Water and sediment transport from the uplands is seldom a problem with rainfalls less than 1.3 cm per day (Harmon and Duncan, 1978).

Figure 2 shows the normal annual precipitation for Iowa based on weather records from 1941-70. This map shows a general trend of increasing precipitation from the northwest corner of the state to the southeastern part.

About 60% of the annual precipitation is received during

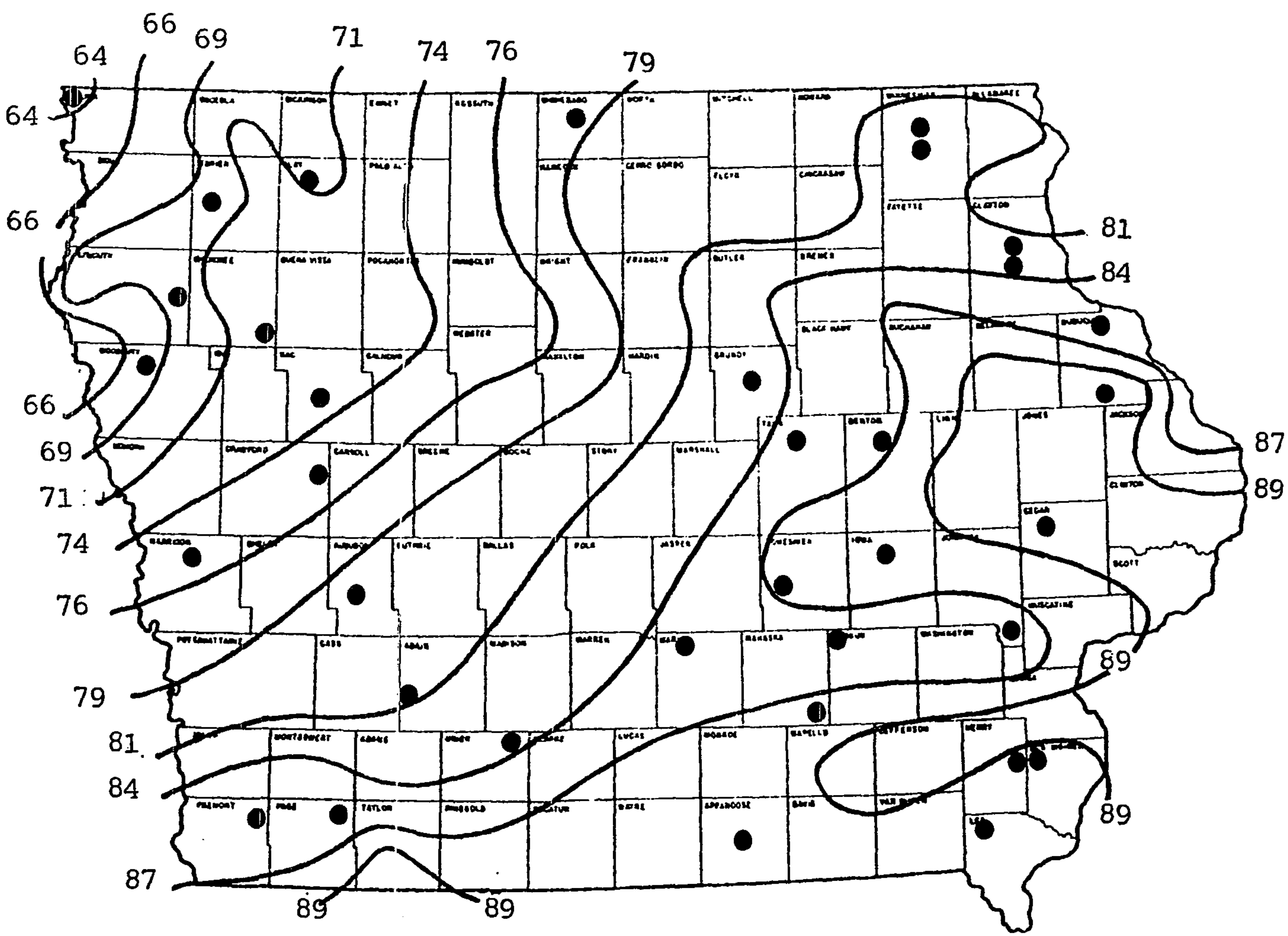


Figure 2. Normal annual precipitation for Iowa in cm (1941-70)
(● Colo sample sites) (Harmon and Duncan, 1978)

late spring to late summer (Figure 3). Maximum intensity of precipitation occurs in June while the minimum occurs in January and February (Visher, 1954).

Another form of precipitation is snowfall. Usually, snowfall does not contribute appreciable amounts of moisture for crop production but does contribute to runoff. As a guide, 25 cm of snow melts to 2.5 cm of water. Figure 4 shows the annual seasonal snowfall in Iowa and Figure 5 shows the average number of days with 2.5 cm or more of snow cover. Snow cover was utilized by Castro-Morales (1978) as a climatic variable to calculate monthly water balances and to estimate soil moisture and soil temperature regimes. The amount of snowfall and the duration of snow cover are important because these factors have a direct effect on field conditions and seedbed preparations in the spring.

The mean annual air temperature (MAAT) ranges from $8^{\circ}C$ in the northern part of the state to $11.5^{\circ}C$ in the extreme southeast corner of the state (Figure 6). Northwesterly winds from Canada bringing cold air dominate during the winter months while southerly winds from the Gulf of Mexico bringing warm air are frequent during April to October. Normal temperatures for Iowa by months from 1941-1970 are presented in Figure 7.

Soil moisture and soil temperature may be related to climatic information. A number of methods have been devised to relate soil moisture to meteorological records. All of

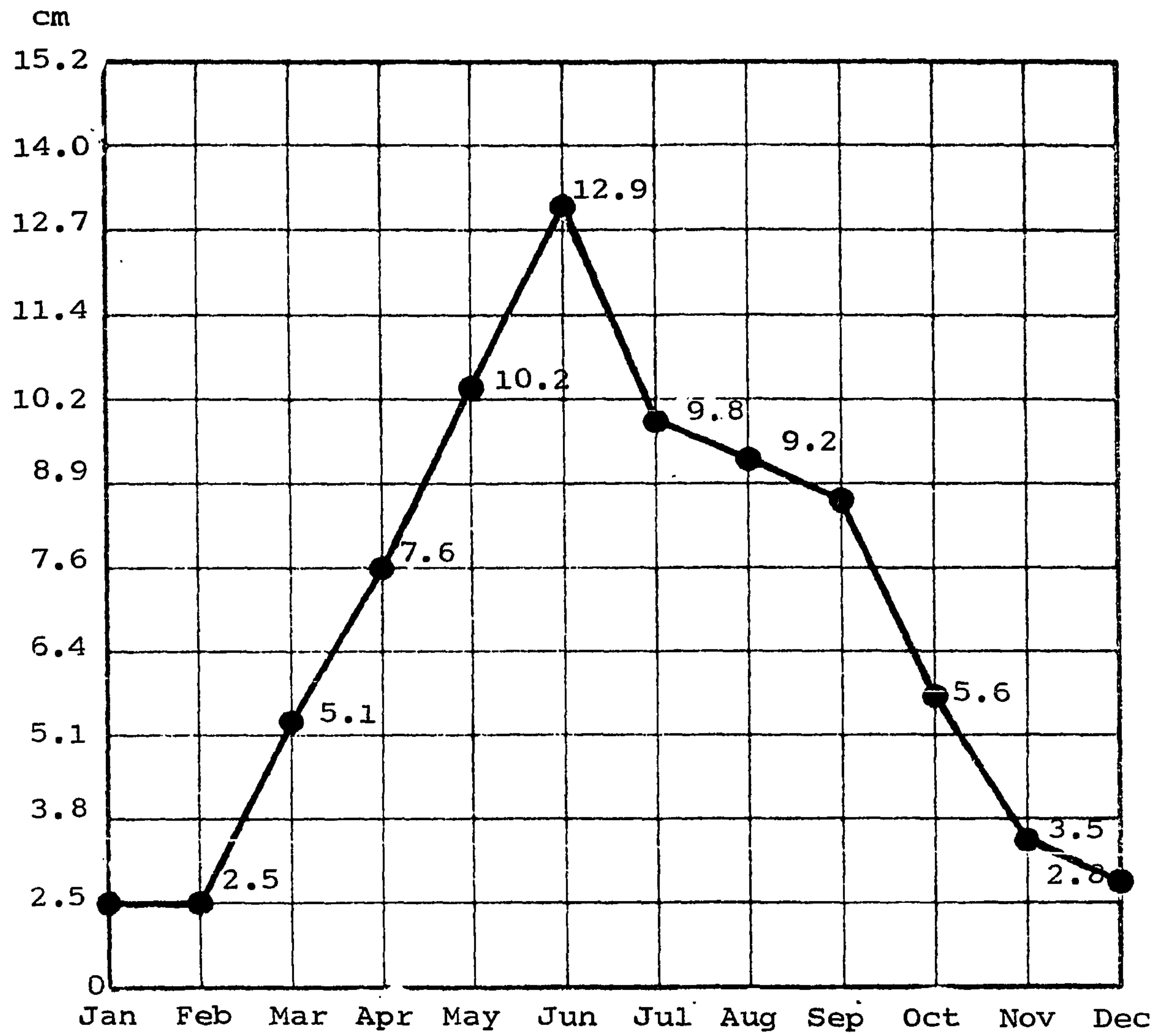


Figure 3. Normal monthly precipitation for Iowa in cm (1941-1970) (Harmon and Duncan, 1978)

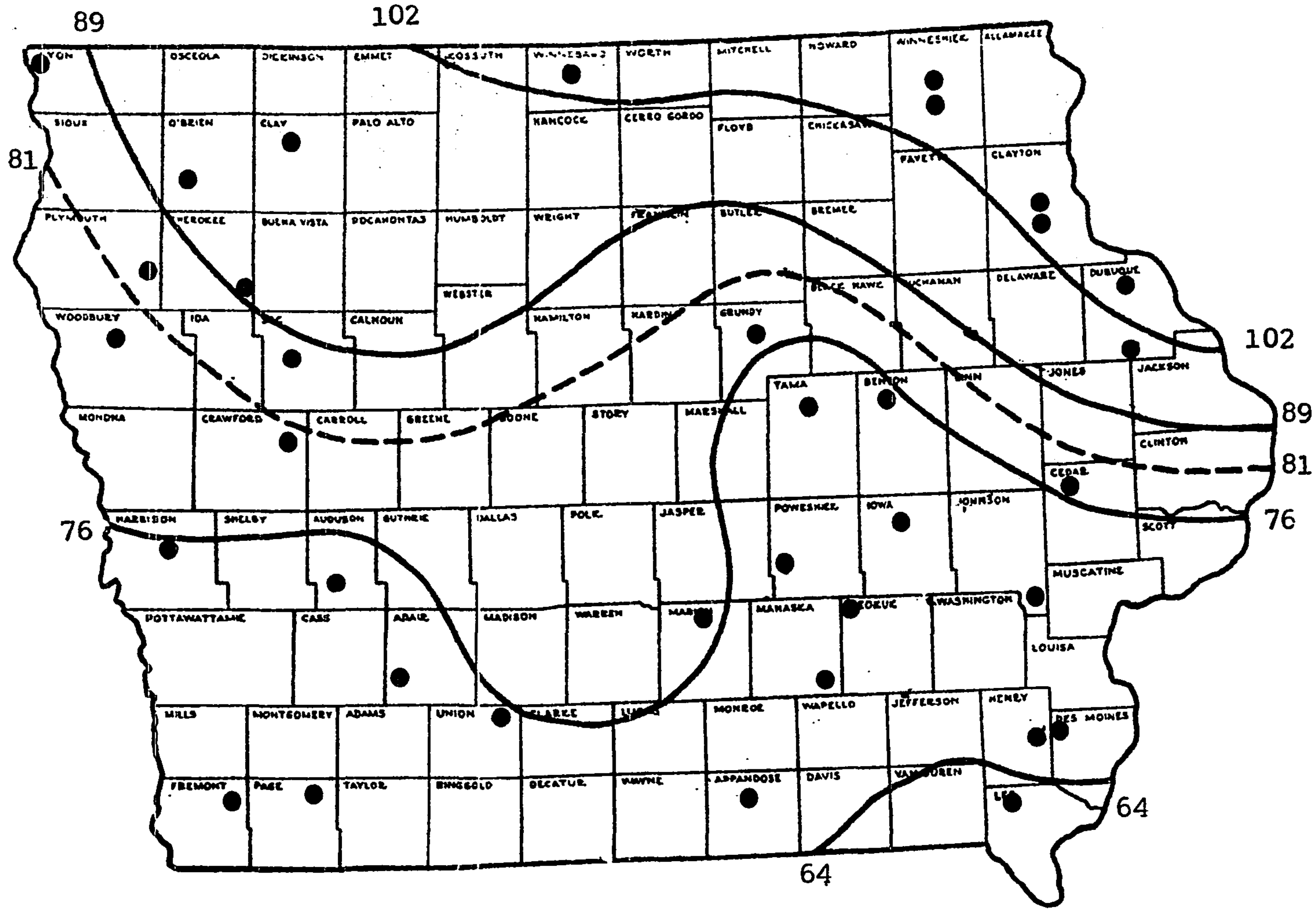


Figure 4. Average seasonal snowfall in cm (● Colo sampled sites)
(Harmon and Duncan, 1978)

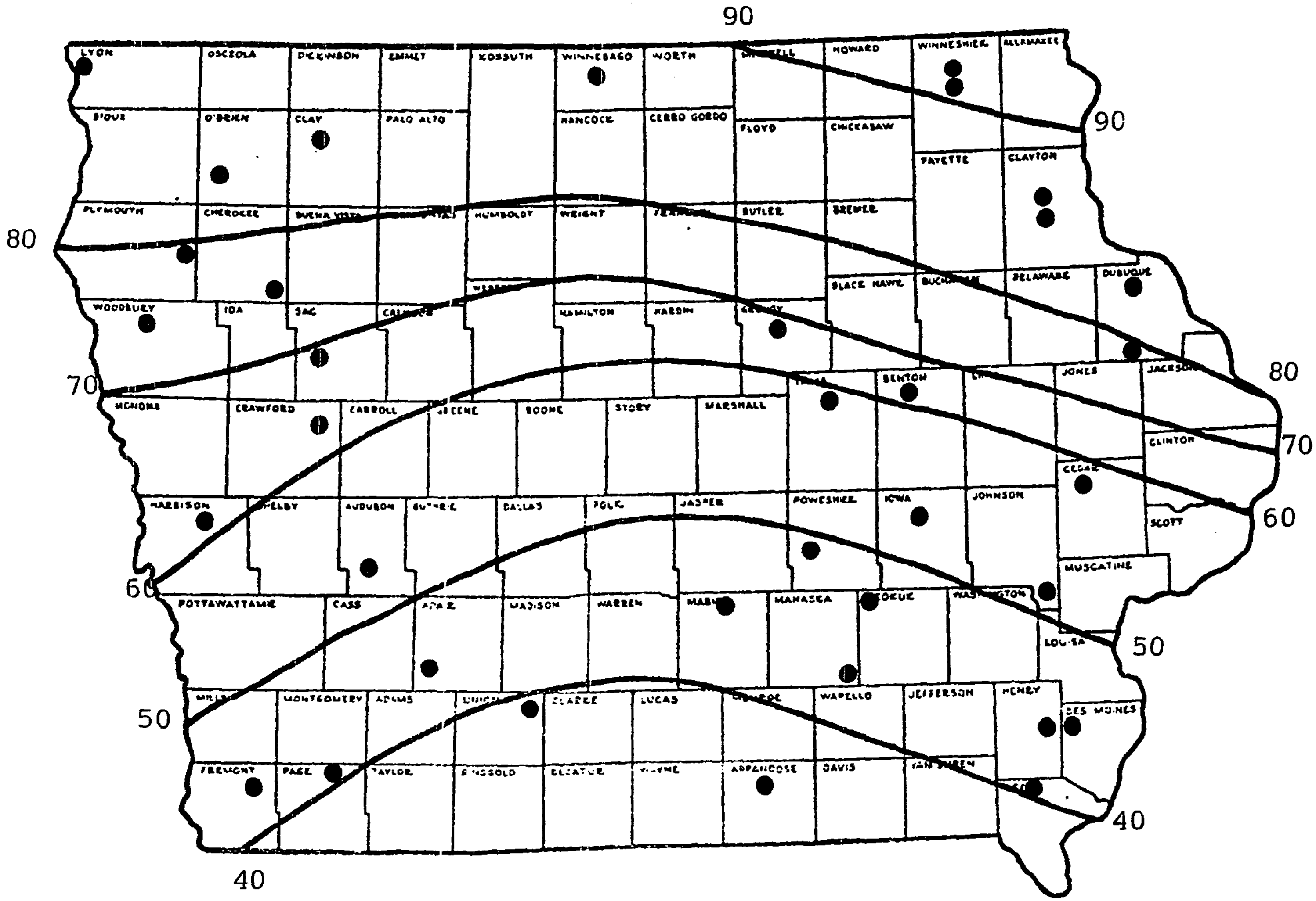


Figure 5. Average annual number of days with snow cover 2.5 cm or more (● Colo sampled sites) (Harmon and Duncan, 1978)

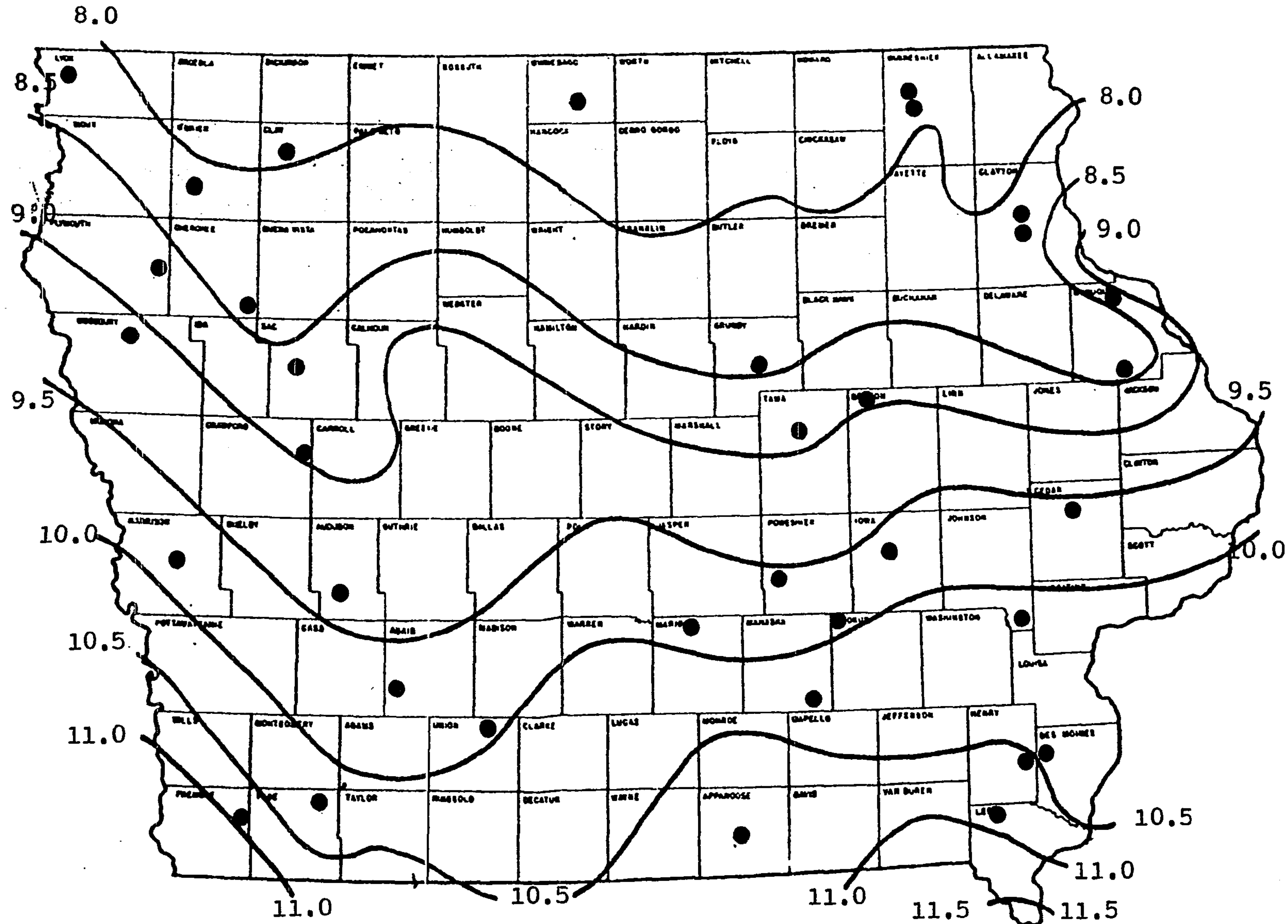


Figure 6. Mean annual air temperature isolines in °C (1941-1970)
(● Colo sampled sites)(Harmon and Duncan, 1978)

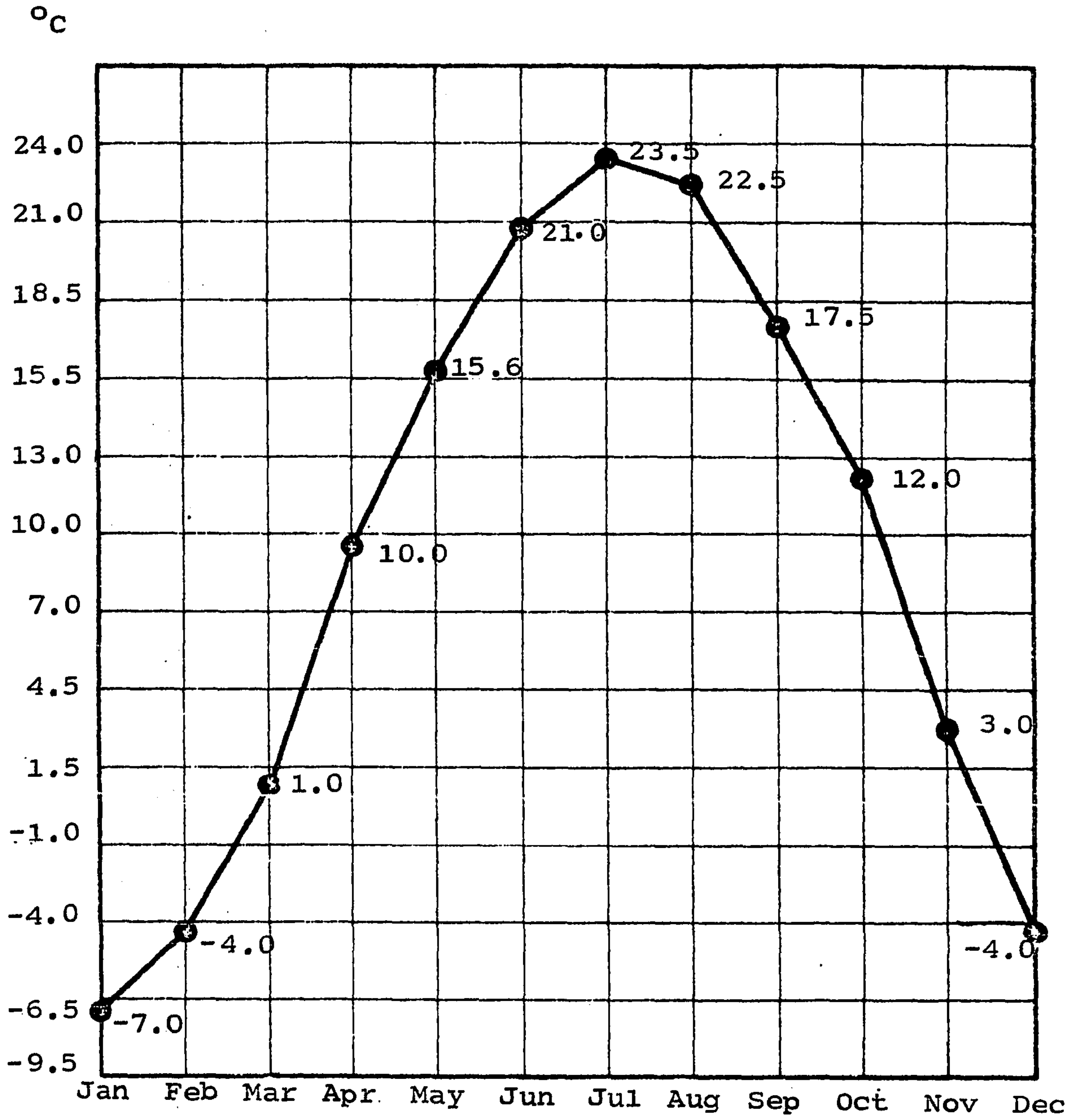


Figure 7. Normal monthly temperatures for Iowa in °C (1941-1970) (Harmon and Duncan, 1978)

these methods have some shortcomings (Mather and Thornthwaite, 1964). Castro-Morales (1978) presented the most in-depth study on the relation of soil moisture and soil temperature to climatic data in Iowa. Other information may be obtained from Harmon and Duncan (1978).

Soil moisture and soil temperature are also important in the present classification scheme. A soil moisture control section and a soil temperature control section are defined in Soil Taxonomy (Soil Survey Staff, 1975b).

The purpose in defining the soil moisture control section is to facilitate estimation of soil moisture regimes from climatic data. The area in the soil defined as the control section is determined by the method outlined in Soil Taxonomy (Soil Survey Staff, 1975b). The Colo soil has an aquic moisture regime which implies a reducing environment lacking dissolved oxygen.

Soil temperature is an important soil property because within limits temperature controls the possibilities for biological activity (animals and plant growth) and soil formation (physical and chemical weathering). Mean annual soil temperature is related to the mean annual air temperature but is affected by the amount and distribution of precipitation, soil moisture, the protection by shade, slope aspect and gradient, irrigation and soil properties. The mean annual soil temperature (at 20 cm) for much of the United States could be estimated by adding 1°C to the MAAT.

Other ways are discussed in Soil Taxonomy (Soil Survey Staff, 1975b).

Soil temperature regimes based on the mean annual soil temperature are used in defining classes at various categorical levels in taxonomy. All soils in Iowa, including the Colo soil series, have a mesic soil temperature regime ($8^{o}C$ to $15^{o}C$ and the difference between mean summer and mean winter soil temperature is more than $5^{o}C$ at a depth of 50 cm). Colo soils sampled in Dakota County, Minnesota and Lafayette County, Missouri border the frigid and thermic soil temperature regimes, respectively. Their closeness to colder or warmer temperature may influence some physical and chemical properties in the soil.

Vegetative influence

Iowa's original forest cover, based on data obtained in the original land survey made in Michigan, Wisconsin, and Iowa territories between 1832-1859 when all sectional lines and townships were established, was associated with major drainage areas of the state (rolling to steep uplands along rivers and tributaries) (Figure 8). The original deciduous (oak-hickory) forest covered less than one-fourth of the state. Areas of forested land were larger and more prominent in eastern Iowa than other areas of the state. More than three-fourths of the state was prairie (primarily big bluestem, Andropogan gerardi) or a mixture of prairie and trees. Prairie areas

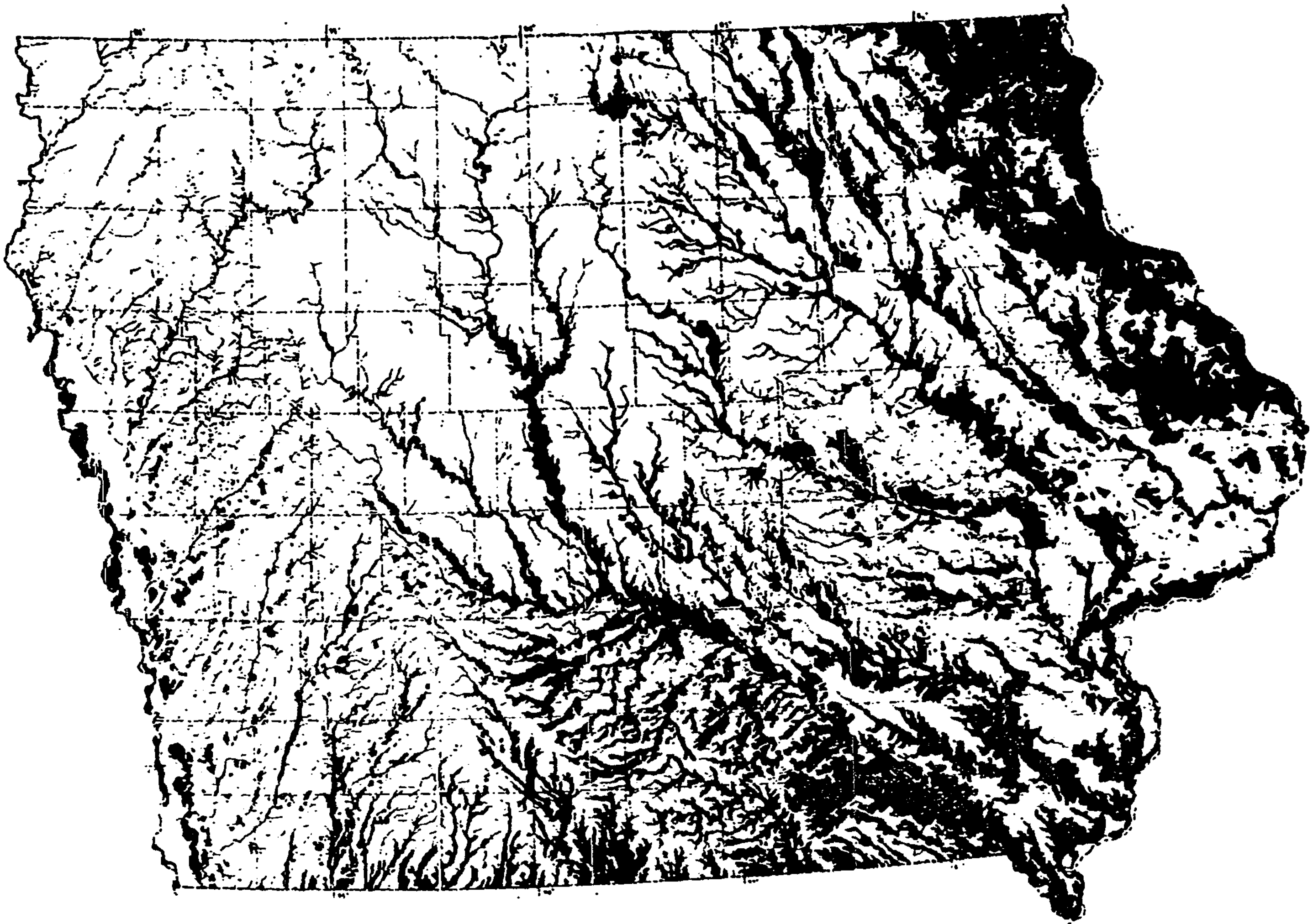


Figure 8. Iowa's original forest cover (from original land survey completed in 1859)

were located on the broad undulating to gently sloping uplands (Simonson et al., 1952).

A number of important morphological and chemical and physical properties differ in Iowa soils due to native vegetation. Big bluestem reached heights ranging from 1.8 to 2.4 m forming a very tough fibrous root system (Smith et al., 1950). Its decomposition added considerable amount of organic matter to the surface and underlying horizons. Therefore, soils influenced by prairie vegetation usually have deep, dark-colored surface horizons, whereas, those soils influenced by forest vegetation have thin, moderately dark A1 horizons but thicker light-colored A2 horizons. In general, other morphological differences include texture and structure of the A and B horizons (Collins, 1977; Shrader, 1950; White and Riecken, 1955). Chemical differences (pH, available phosphorus, total phosphorus, total carbon) are discussed by Collins (1977), Pearson, Spry and Pierre (1940), Fenton, Riecken, and Seaholm (1967), Runge and Riecken (1966), and Tembhare (1973) to mention a few.

The influence of vegetation on soil development, historically, has also affected soil classification systems. Soils were classified according to the flora that it supported. For example, there were corn soils, cotton soils, or prairie soils (Coffey, 1912). Presently, in Soil Taxonomy (Soil Survey Staff, 1975b), soils formed under forest vegetation are generally classified in the Alfisol order and soils formed under grass vegetation are often classified in the Mollisol order.

Also, it should be mentioned that climate and vegetation patterns may have changed during soil development (Ruhe and Scholtes, 1956). Paleobotanical and paleoclimatical information show evidence of change during the Pleistocene. Evidence recorded by Ruhe and Scholtes (1956), Ruhe (1969), and Walker (1966) indicate past environments ranged from cool and moist (mostly spruce and hemlock) to warm and dry (mostly prairie grasses). A more thorough discussion of paleobotanic and paleoclimatic information is mentioned in the references.

Climatic and vegetative changes through the Pleistocene have a greater effect on upland soils than those soils formed from alluvial parent material. In many areas, the parent material, alluvium, is Recent in age. Therefore, changes during the Pleistocene had no effect on soils derived in this "recent" parent material. However, the sediments eroded from upland soils, transported into the watershed and deposited on floodplains may have been influenced by climatic and vegetative changes.

Climatic Water Balance

Thornthwaite in 1945 presented the concept of climatic water balance in an effort to qualify the climatic factors that determine the relative moistness or dryness of an area. He showed that the moisture condition of an area could not be determined from only precipitation data. Rather, a balance between precipitation and evapotranspiration was a more suitable parameter. To apply the concept of climatic water balance, the daily or monthly relationship between precipitation and evapotranspiration which provides information on periods and quantities of moisture surplus and moisture deficiency must be known. This information contributes directly to our knowledge on irrigation water needs, stream runoff, ground water recharge, and soil moisture storage (Mather and Thornthwaite, 1964).

Information summarized by Mather and Thornthwaite (1964) on the climatic water balance in Iowa relative to the study sites is presented in Figures 9, 10 and 11. The data included in the water balance figures are average yearly potential evapotranspiration (PE), actual evapotranspiration (AE), water surplus, and moisture index. The water surplus and moisture index are calculated using other climatic data. The moisture index was calculated using the equation $I = 100(\frac{P}{PE} - 1)$ (P=precipitation) and the results are presented in Figure 12. Moist climates have positive values of I; dry climates have negative values. Water surplus was calculated using the equation P - AE and the results are presented in Figure 11. By definition, the water surplus is the amount of water which does not remain in the surface soil but is the water available for deep percolation to the water table or subsurface flow to streams. Thus, information on water surplus determined from

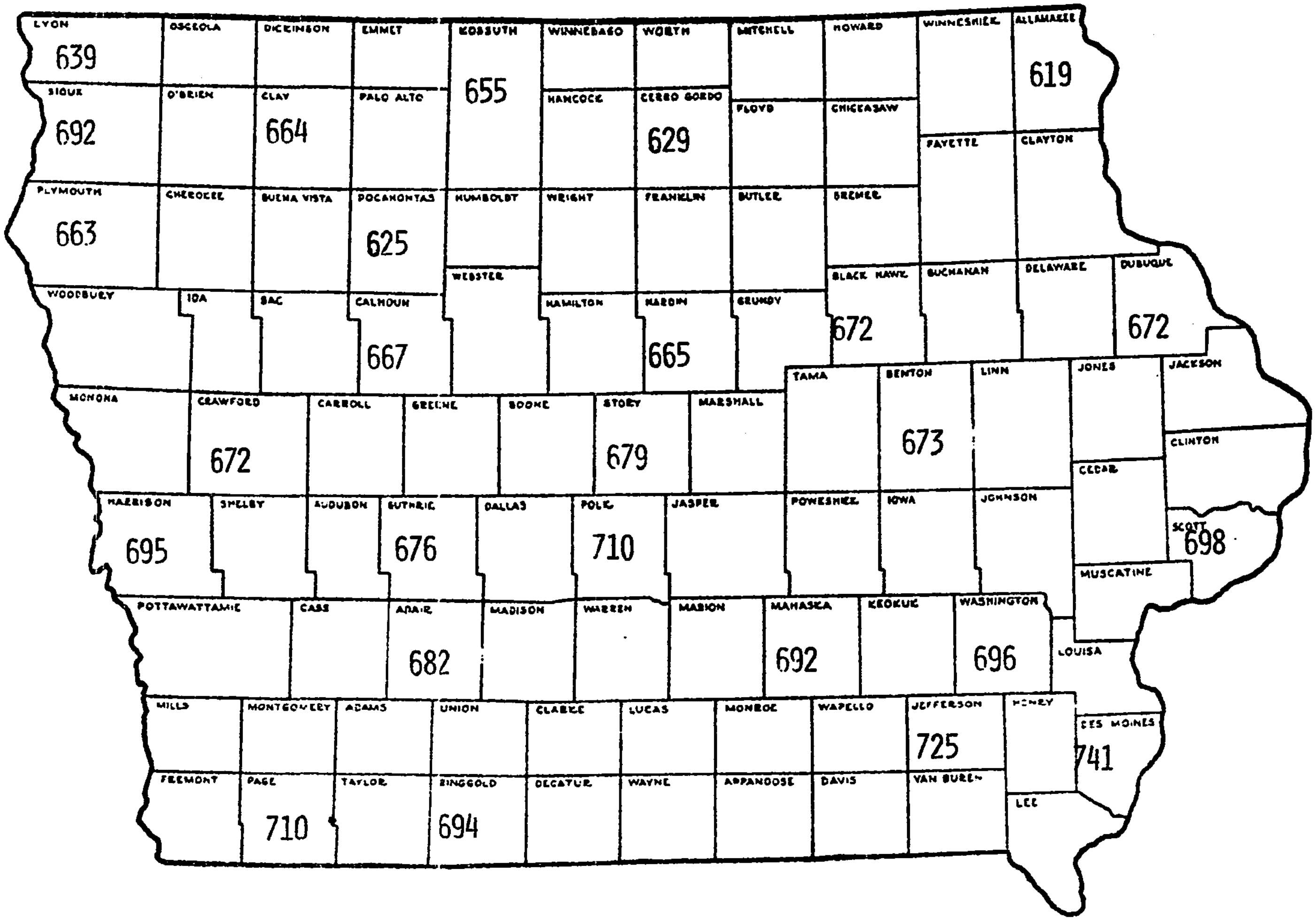


Figure 9. Annual potential evapotranspiration for Iowa in mm

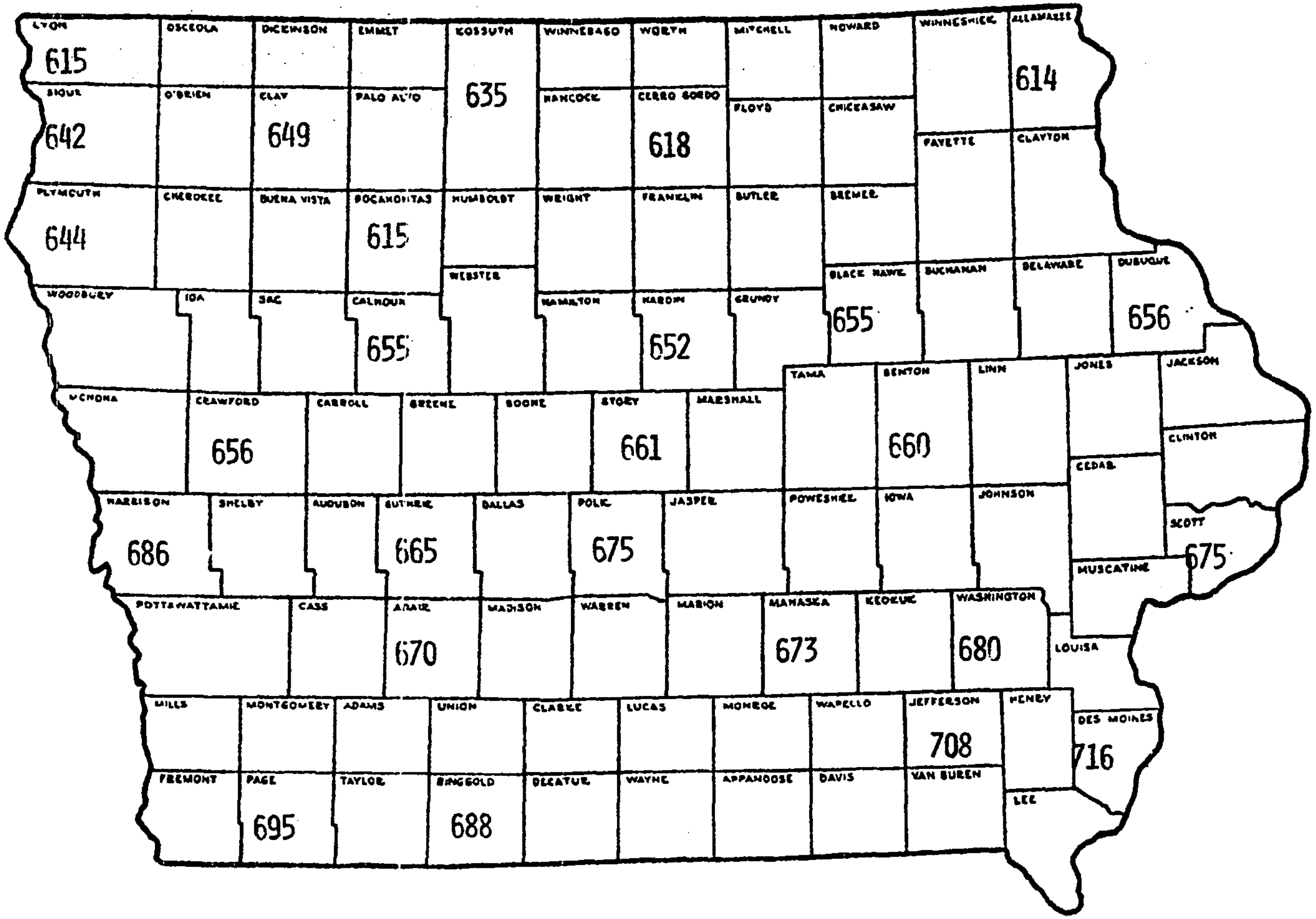


Figure 10. Annual actual evapotranspiration for Iowa in mm

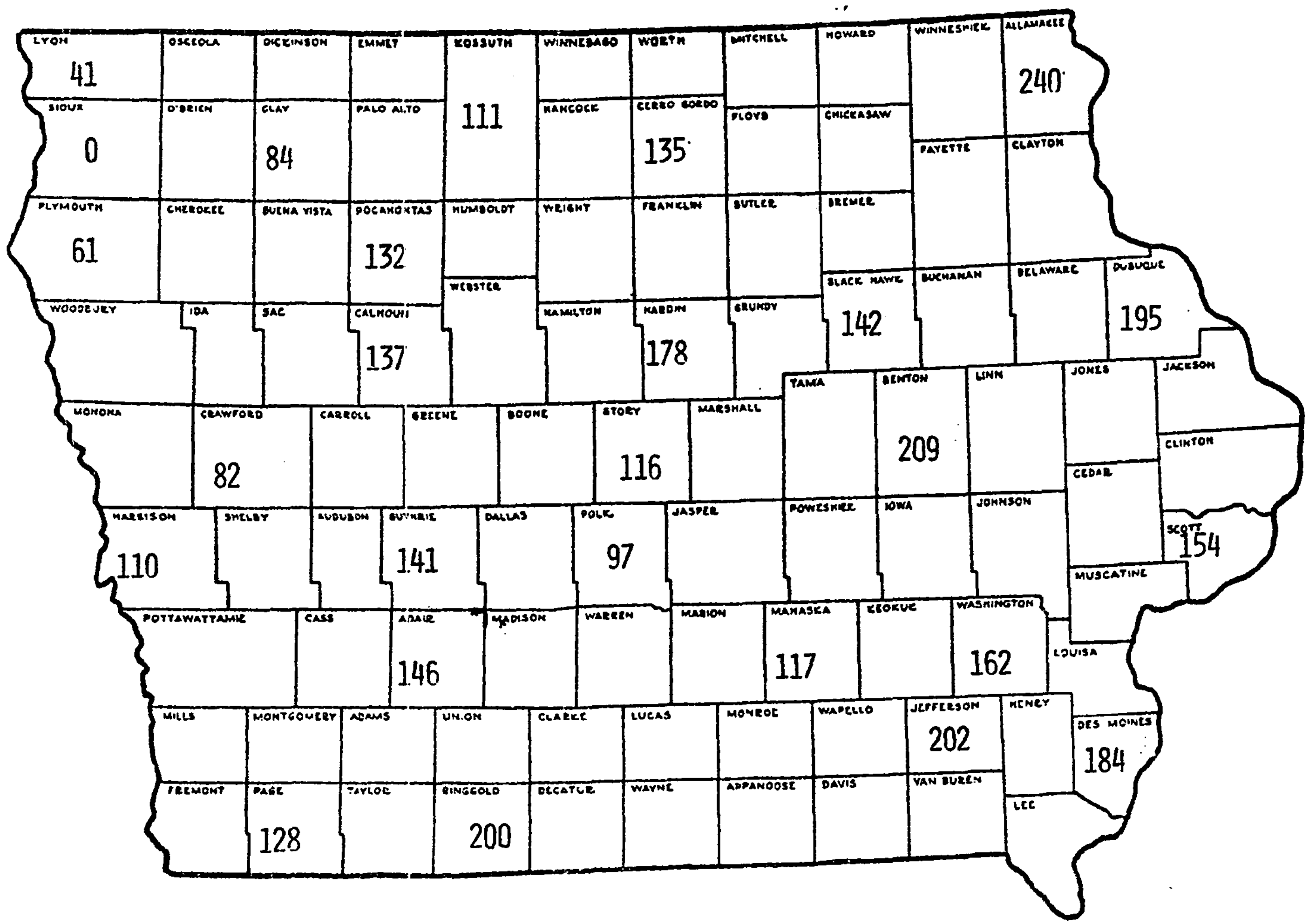


Figure 11. Annual water surplus for Iowa in mm

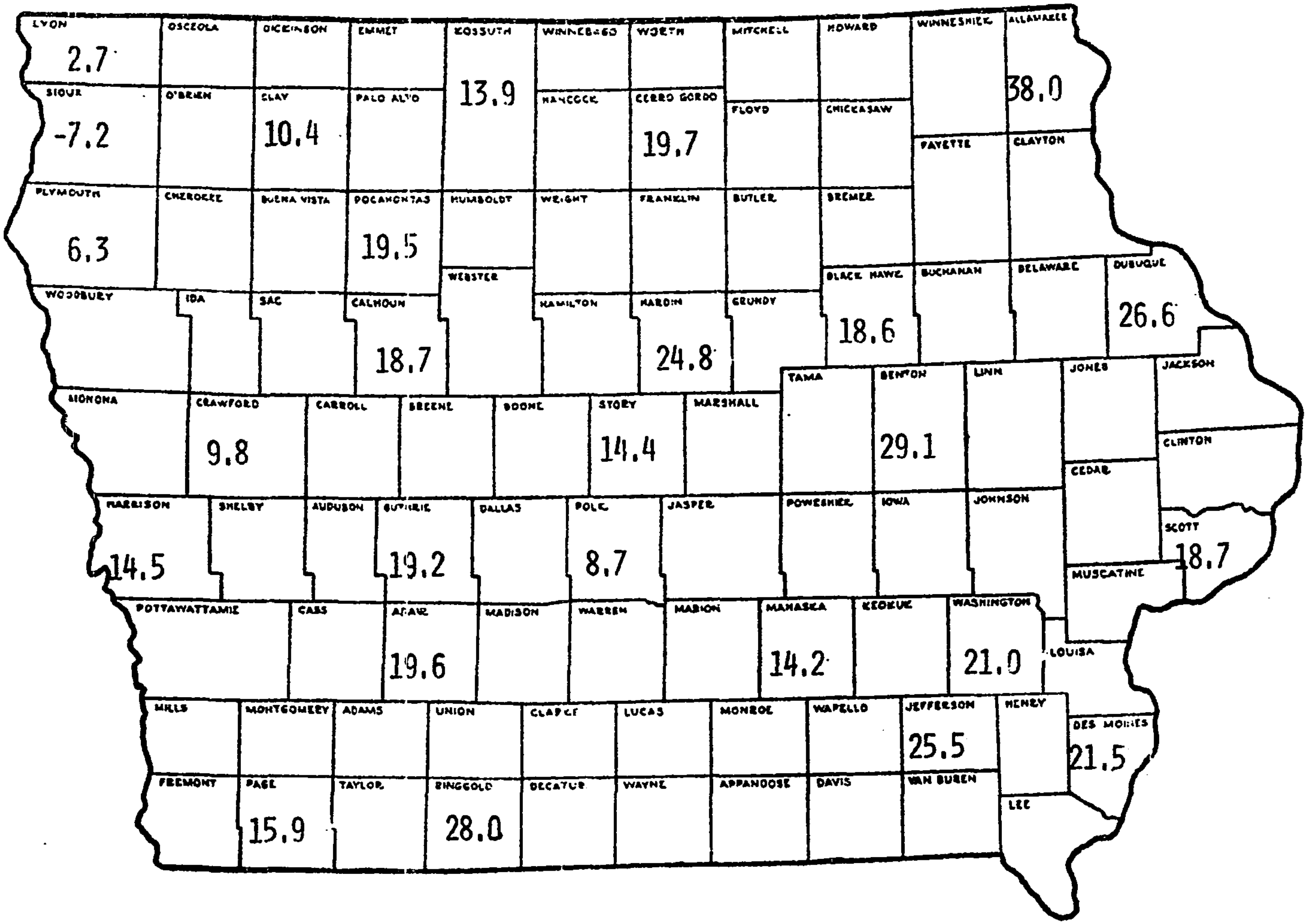


Figure 12. Calculated moisture index for Iowa

the water balance gives an indication of stream flow.

In Iowa, water surplus varied from 240 mm in Allamakee County to 0 mm in Sioux County. Moisture indices ranged from -7.2 mm in Sioux County to 38.0 mm in Allamakee County. Potential evapotranspiration ranged from 741 mm in Des Moines County to 619 mm in Allamakee County, while actual evapotranspiration varied from 716 mm in Des Moines County to 614 mm in Allamakee County. Information such as Mather and Thornthwaite (1964) should be used for long-term research projects.

The Influence of Time, Topography, and Parent Materials on Iowa Soils

Time is a factor of soil formation. The amount of time needed is related to certain environmental conditions, e.g., influence of topography, influence of climate. In soil genesis studies, two factors of time should be separated: (1) the age of the parent material and (2) the amount of time needed for a soil to form from parent material. The recognition of two time factors is important because the age of the parent material is not necessarily the age of the soil. Parent material may be hundreds of thousands of years old but the soil developed in that material may be only several thousand years old, e.g., soils on the Iowan Erosion Surface.

Dating the parent material may involve a relative method or an absolute method. In a relative method, the parent material may be younger, older, or the same age as another feature. Fortunately, a clock has been built into naturally occurring objects in the form of radioisotopic elements (Ruhe, 1969). Radioactive decay of these elements and its measurements are a means of absolute dating. The absolute means of dating was not used in this study. Therefore, a brief explanation of the relative method will be discussed.

The principle of superposition and the principles of ascendancy and descendancy are important rules to follow in relative dating. The principle of superposition applies if the sediments have been deposited on an essentially horizontal plane. Thus, the younger beds are on top of the older beds. Ruhe (1969) stated,

> Consequently, at any place the youngest bed will be at and immediately beneath the land surface, and successively older beds will be at greater depths.

This is only true if distortion and deformation of the beds by earth movements have not occurred after deposition.

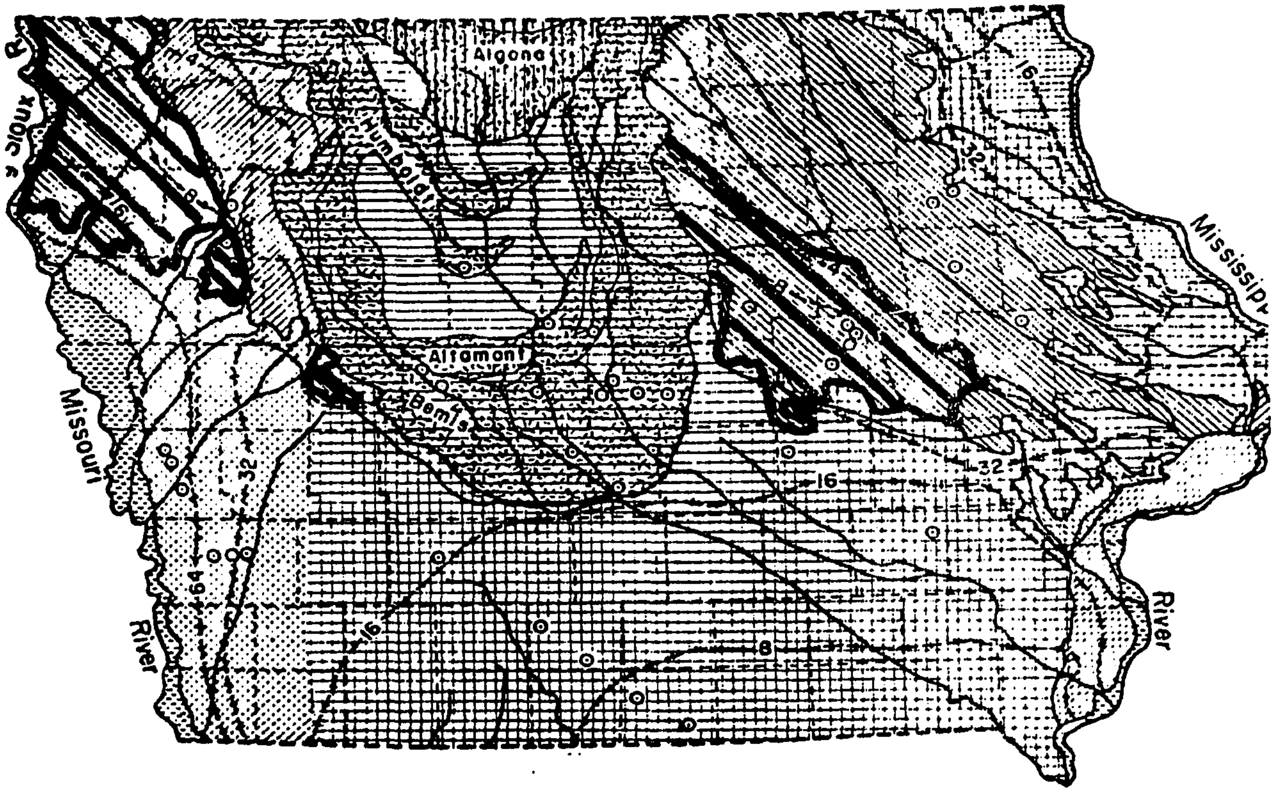
It may be difficult to apply the principle of superposition in complex landscapes. Ruhe (1969) mentioned,

> If a stream incises a valley and deposits sediment, this younger material may be a considerable distance below an older bed that is just beneath the land surface at the top of the adjacent hill. In the valley alluvium itself, a channel-fill deposit may be inset below the top of an older alluvial bed.

The principles of ascendancy and descendancy states that the hillslope is the same age as the alluvial valley fill to which it descends, but is younger than the higher surface to which it ascends. Therefore, the hillslope surface is younger than the uppermost bed inside the hill. Also, the hillslope is younger than the land surface at the top, the summit of the hill. The uppermost alluvial fill in the valley must be the same age as the hillslope. Erosion has occurred on the hillslopes and this eroded material provides the sediment that was deposited at the base of the hillslope. More information on the uses of relative and absolute methods in soil genesis studies is given by Ruhe (1969).

The principle of superposition and principles of ascendancy and descendancy may by relative dating methods give the time factor in Jenny's soil forming factor equation. If the hillslopes are dated by an absolute method, the principle of descendancy could be applied and, therefore, a time frame could be obtained of soil development in alluvial sediments.

The time variable in the soil forming factor equation in Iowa ranges from one million years before present (YBP) (Nebraska glacial period) to today. The State of Iowa was glaciated four major times during the Pleistocene. The major glacial periods were from oldest to youngest: Nebraskan (about 750,000 YBP), Kansan (about 500,000 YBP), Illinoian (about 150,000 YBP), and Wisconsin (29,000 to 12,000 YBP) (Wright and Frey, 1965). The Nebraskan and Kansan glaciers covered the entire state of Iowa. Illinoian drift is thought to have been deposited in southeastern Iowa (Hallberg et al., 1980), while Illinoian loess (Loveland) is located in western Iowa (Figure 13). The Loveland loess was deposited on the



CARY I DRIFT

CARY II DRIFT

ALLUVIUM

END MORAINE

IOWAN EROSION SURFACE, LOAM SEDIMENT MANTLE

RADIOCARBON SITES

WISCONSIN LOESS THICKNESS - FEET

WISCONSIN LOESS MANTLE[1/] OVER:

IOWAN EROSION SURFACE ON TAZEWELL DRIFT

IOWAN EROSION SURFACE ON KANSAN AND/OR NEBRASKAN DRIFT

LOVELAND (ILLINOIAN) LOESS

ILLINOIAN DRIFT

GLACIAL LAKE CALVIN BEDS

KANSAN AND/OR NEBRASKAN DRIFT

"DRIFTLESS" AREA (PATCHY DRIFT OVER BEDROCK)

[1/] In many areas, loess will mantle summits and glacial drift will outcrop on sideslopes.

Figure 13. Quaternary geology of Iowa (Wright and Frey, 1965) modified by Fenton (T. E. Fenton, Department of Agronomy, I.S.U., unpublished data)

pre-existing land surface. This land surface was of Yarmouth age. Yarmouth was an interglacial period between the Kansan and Illinoian glaciation. During this period, the landscape was subject to erosion, deposition, weathering, and soil formation. Other interglacial periods were the Aftonian between Nebraskan and Kansan, and Sangamon between Illinoian and Wisconsin. The Recent began after Wisconsin glaciation and continues today. Paleosols such as a Yarmouth-Sangamon paleosol are soils that formed on paleo-landscapes (Ruhe, 1969) during previous interglacial periods. These soils may be exposed on sideslopes throughout parts of the state.

During the Wisconsin glacial period, loess was deposited from approximately 29,000 YBP to 14,000 YBP (Ruhe, 1969). Wisconsin loess covers most of Iowa except the Cary lobe and most of the Iowan Erosion Surface (Figure 13). Wisconsin loess is beneath the Wisconsin glacial till on the Cary lobe. The Wisconsin glacial till by radiocarbon dating is approximately 14,000 to 12,000 years old on the Cary lobe. The Iowan Erosion surface is an erosional surface cut into Kansan and Nebraskan till (Ruhe, 1969).

Since the Wisconsin loess and Wisconsin till are the dominant parent materials of soils formed in Iowa, the following discussion will be restricted to the influence these parent materials have on soil development in Iowa. Figure 14 shows the major loess deposits and thickness throughout

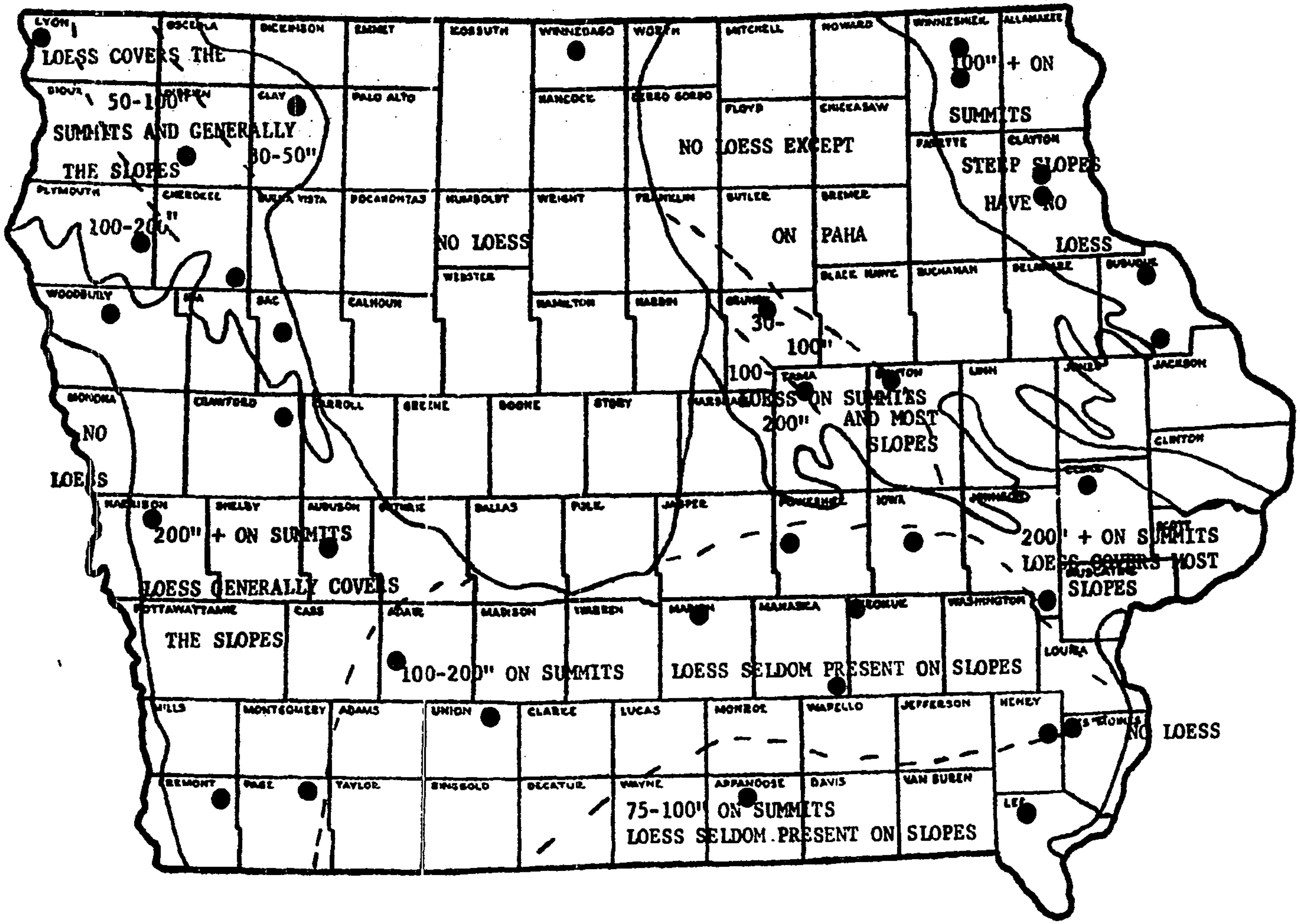


Figure 14. Generalized loess deposits map of Iowa (● Colo sampled sites)

the state. Many research projects have been concerned with the distribution of loess in the state of Iowa. Some important conclusions of those research projects were: (1) that the loess progressively thins away from source, (2) the amount of coarse silt decreases away from source, and (3) the amount of clay-size particles increases away from source (Ruhe, 1969). The Wisconsin loess was deposited on the pre-existing landscape. The topography of areas covered by loess varies from very strongly sloping along the Missouri bluffs in western Iowa and the limestone influenced topography in northeast Iowa to gently sloping in the northwest corner of the state (Figure 15).

The Wisconsin till in the Cary lobe area of the state has four end moraines: Bemis, Altamont, Humboldt, and the Algona. The Cary lobe has gently sloping topography except for morainal areas which may have short steep slopes. Other morphostratigraphic units that comprise the Cary lobe are gound moraines, outwash plains, and valley trains. These glacial features have influenced the topography of the lobe.

Soil Forming Factors of Areas in Neighboring States

Missouri

The parent materials of soils in counties in which Colo soils were sampled in Missouri are loess, glacial till, alluvium, and residium or a combination of these materials.

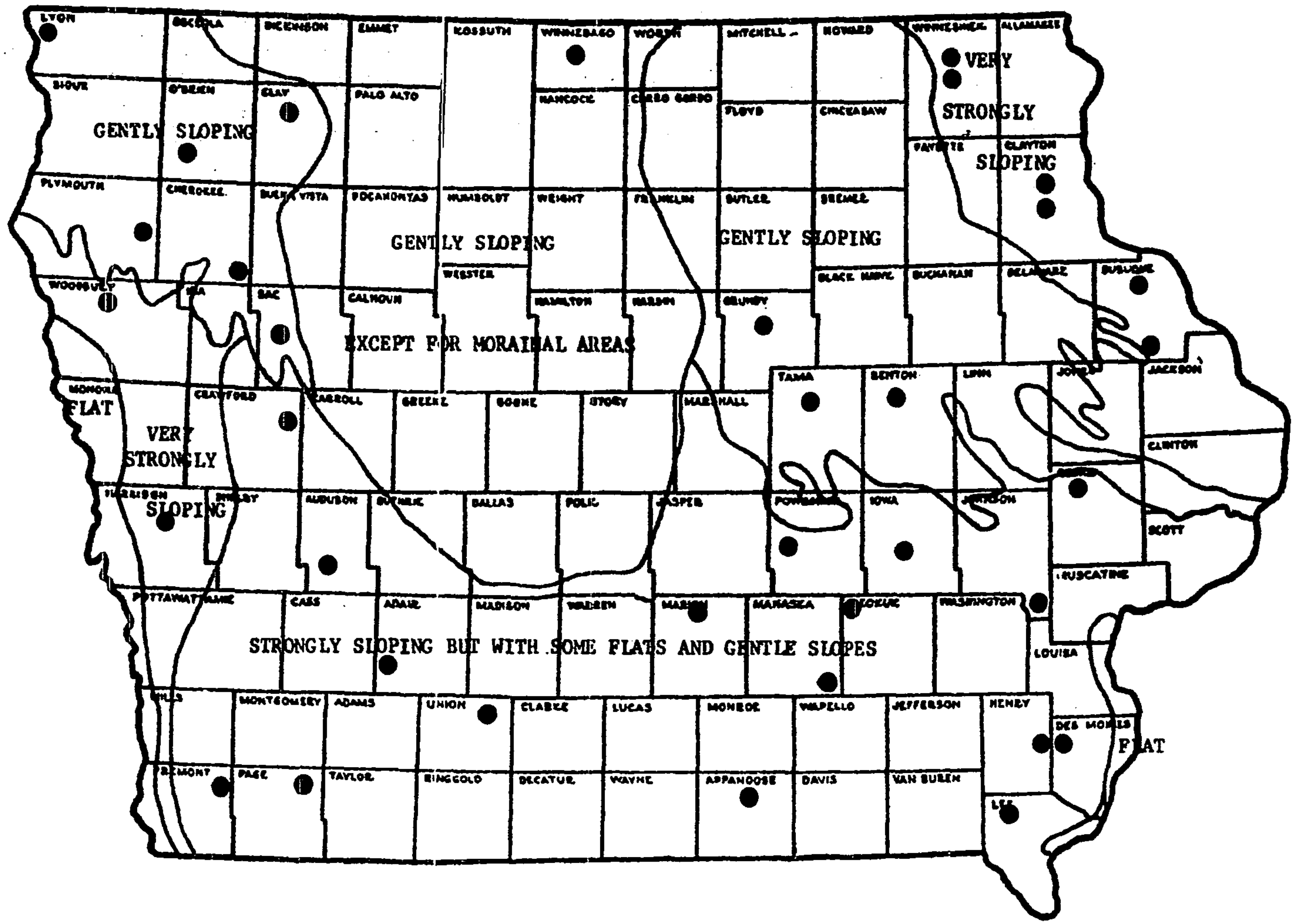


Figure 15. Generalized topographic map of Iowa (● Colo sampled sites)

Loess was probably blown from the larger floodplains, e.g., the Missouri River, and deposited on the uplands. Loess remains on most of the wider ridges and is as great as 3 meters thick in some areas. The Kansan glacier completely covered Scotland County and, presumably, Harrison County many thousands of years ago. In other counties in which samples were obtained, the period of glaciation is not mentioned. The glacial till ranges in thickness from a few meters to more than 100 meters and was calcareous when deposited. Alluvial parent material in some counties is of a local source. The material is made up of silt, sand, clay, and gravel transported by water from ridges and hillsides to adjacent floodplains of streams. In other counties, the alluvial parent material comes from sources miles upstream. Residual material has weathered from limestone, sandstone, and shale to form the parent material of some soils in the counties (Watson, 1974; Minor, 1979; Jeffrey, 1974, 1975).

The climate of northern Missouri is similar to the climate of southern Iowa. This area of Missouri has a typical continental climate characterized by frequent changes in temperature, humidity, cloudiness, and winds. For example, in winter it is not uncommon for the temperature to rise to 15^{o}C one day and then drop to -18^{o}C the next day. Climatic information for Scotland, Harrison, Caldwell, and Lafayette counties is presented in Table 1. As discussed earlier, the climate in northern Missouri has not been stable during soil

Table 1. Climatic information for Scotland, Harrison, Caldwell, and Lafayette counties, Missouri

County	Average yearly temperature (°C)		Average yearly precipitation (cm)		Length of growing season (days)
	Maximum	Minimum	Rainfall	Snowfall	
Scotland[a]	17.5	4	86	61	172
Harrison[b]	18	4.5	83	68	141
Caldwell[c]	18.5	5.5	90	57	179
Lafayette[d]	19	7	97	58	196

[a]Watson (1975).

[b]Minor (1979).

[c]Jeffrey (1974)

[d]Jeffrey (1975).

formation.

Soil formation has been affected by tall prairie grasses, a mixture of tall prairie grasses and deciduous forests, or deciduous forests. The type of vegetation is a direct result of the type of climate. Therefore, when the climate in Missouri changed during the Sangamon period and other periods, the vegetation also changed (Jeffrey, 1975).

Physiographically, the counties are characterized by gently rolling to hilly uplands and level to nearly level floodplains. The relief in Caldwell County is the result of a well-dissected plain with many ridges and valleys. In the western and northwestern part of the county, elevations are greater than 300 meters. The lowest point in the county is about 216 meters above sea level. The elevation in Harrison County ranges from 234 meters in the southeastern part to 354 meters in the northwestern corner. Along the eastern border of the county, a floodplain that on the average is 3.6 kilometers wide extends the length of most of the county.

The degree of profile development is reflected by the length of time the parent material has been subject to weathering. In general, in northern Missouri the parent material of upland soils varies in age from Late Wisconsin-Recent age (probably 11,000 to 14,000 years ago) to Late Sangamon (about 38,000 years ago) (Ruhe, Daniels, and Cady, 1967) and Yarmouth interglacial period (more than 150,000 years ago) (Ruhe, Rubin, and Scholtes, 1957). Soils formed in old parent material are not necessarily as "old" as the parent material. Profile development may be lacking because of external factors, e.g., steep slopes.

Illinois

The parent materials of soils in Logan and Champaign counties are loess, colluvial sand, alluvium, glacial outwash, and glacial till (Hudelson, 1974; Alexander, Fehrenbacher, and Hallbick, 1974). In Logan County, the Wisconsin loess ranges in thickness from 3 to 3.6 meters on the nearly level upland areas. The glacial till, which is either of Wisconsinan age or Illinoian age, outcrops on steep slopes. Stream valleys contain glacial outwash deposits in the form of terraces (Hudelson, 1974). The Champaign-Urbana area lies within the region covered by the Kansan, Illinoian, and Wisconsinan glaciers. The thickness of the glacial material ranges from about 30 meters in the southeast corner of the county to about 120 meters near the northwest part of the county. Loess covers the entire area and averages 102 to 152 cm in thickness (Alexander et al., 1974). A detailed discussion of the glacial geology in Champaign County is given by Wickham (1979).

Temperature and precipitation data for Logan County and the Champaign-Urbana area are given in Table 2. This county and area of Illinois have a continental climate with hot summers and cold winters.

Tall prairie grasses such as big bluestem dominated the nearly level to gently sloping uplands. Hardwood forests occupied the bottomlands and steeper slopes along the streams. Other areas in the counties were influenced by a mixture of grasses and trees.

The physiography of the areas reflect the nature of ice-deposited glacial features. All of the Champaign-Urbana area is located in the Bloomington Ridged Plain (Leighton et al., 1948) which consists mainly of Woodfordian glacial till of Wisconsinan age. This area of Champaign County is characterized by low, flat or gently undulating moraines (Alexander et al.,

Table 2. Climatic information for Logan County and the Champaign-Urbana Area, Illinois

County or Area	Average yearly temperature (°C) Maximum	Minimum	Average yearly precipi-tation (cm)	Length of growing season (days)
Logan[a]	18	5.5	91	168
Champaign-Urbana[b]	24[c]	-2.5[d]	91	180

[a]Hudelson (1974).

[b]Alexander et al. (1974)

[c]Only the month of January (1899-1946, 1964-1973).

[d]Only the month of July (1889-1946, 1964-1973).

1974). Nearly all of Logan County is in the Springfield Plain, but the northeastern part is in the Bloomington Ridged Plain (Leighton and Brophy, 1961). Broad, nearly level areas are common in the county with sloping areas occurring along the natural drainageways (Hudelson, 1974).

The majority of the soils in Logan County and the Champaign-Urbana Area have formed in Wisconsinan age parent materials.

Minnesota

The soils in Dakota County, Minnesota have extremely variable parent material. The oldest glacial material is the Kansan drift. Illinoian till is located in several areas in the county and the texture of this till ranges from medium or coarse gravel to clay loam. The northern part of the county was covered by the Cary-age terminal moraine of Wisconsin glaciation. There are large areas of outwash material from the Wisconsin glacier. Some of the outwash was originally calcareous (Arneman, 1960).

Waseca County is completely covered by drift of the Mankato substage of the Wisconsin glaciation. The glacial drift ranges from 38 meters to more than 60 meters in thickness (Thiel, 1956). Bedrock is not exposed anywhere in the county.

Waseca and Dakota counties have a cool, subhumid, continental type of climate with wide variations in temperature from summer to winter. Table 3 presents the temperature and precipitation data for these counties.

The soils in Waseco County have been influenced during their formation by forest, prairie, or a combination of both, while in Dakota County there was only forest or prairie native vegetation (Arneman, 1960).

The physiography of Waseca County is influenced by complex, irregular morainic topography. In places, the end moraines and ground moraines have a drumlin-like pattern that is characterized by short, circular hills with smooth sideslopes and nearly level summits (Cummins, 1965). The topography of Dakota County has also been influenced by Wisconsin glaciation. The Cary glacial terminal moraine area of the county is characterized by a knob and kettle or knoll and

Table 3. Climatic information for Waseca and Dakota counties, Minnesota

County	Average yearly temperature (°C)		Average yearly precipitation (cm)		Length of growing season (days)
	Maximum	Minimum	Rainfall	Snowfall	
Waseca[a]	13	1.5	72	100	NA[b]
Dakota[c]	13.5[d]	.8[d]	68	114	139

[a]Cummins (1965).

[b]Not available.

[c]Arneman (1960).

[d]Information not available for Dakota. Reported is for Goodhue County, Minnesota (Poch, 1976).

basin topography. The outwash plain areas are nearly level to gently sloping (Arneman, 1960). Elevations in the county are generally less than 315 meters above sea level.

Geologically and pedologically, the soils of Waseca and Dakota are young. Most of the soils formed in Waseca County between 8,000 and 10,000 years ago (Cummins, 1965).

Nebraska

Soil-forming information was not available for Stanton County, Nebraska. Since Cuming County borders Stanton County on the east (Figure 1), the discussion for the soil-forming factors in Cuming County may also be relative to Stanton County. Justification for this is that soils mapped in Cuming

County are also mapped in Stanton County.

The parent materials for most of eastern Nebraska, which includes Cuming, Washington, and Saunders Counties, are loess, alluvium, and glacial till. In Cuming County, the primary parent material of the soils is Wisconsin loess which averages 6 to 9 meters in thickness but ranges in thickness from a few meters to more than 30 meters (Da Moude et al., 1975). Soils derived from glacial till are not mapped. The parent material of the majority of soils in Washington and Saunders counties is Wisconsin loess. Loveland loess is beneath the Wisconsin loess and superjacent to Kansan till (Elder et al., 1965; Greenawalt and McKinzie, 1964).

The climate of these counties is influenced by their distance from any oceans. They have a continental climate characterized by moderate rainfall, hot summers, severe winters, great annual variations in temperature and rainfall, and frequent daily or weekly changes in weather. Table 4 summarizes the climatic data for Cuming, Saunders, and Washington counties.

Most of the upland soils in eastern Nebraska have been influenced during their formation by native prairie grasses such as big bluestem, Indiangrass, switchgrass, Canada wildrye, little bluestem, prairie dropseed, porcupinegrass, and plains muhly (Da Moude et al., 1975; Greenawalt and McKinzie, 1964). The native vegetation on the loess bluffs and on hillsides near streams was mostly trees, principally green ash, hackberry,

Table 4. Climatic information for Cuming, Saunders, and Washington counties, Nebraska

County	Average yearly temperature (°C)		Average yearly precipitation (cm)		Length of growing season (days)
	Maximum	Minimum	Rainfall	Snowfall	
Cuming[a]	16	3.5	72	86	160
Saunders[b]	25.3[c]	-4.5[d]	70	74	NA[e]
Washington[b]	16.5	4.5	67	75	166

[a]Da Moude et al. (1975).

[b]Elder et al. (1965).

[c]Average of January, coldest month.

[d]Average of July, warmest month.

[e]Not available.

bur oak, American elm, and Russian mulberry. Native prairie grasses along the streams were prairie cordgrass, switchgrass, reed canarygrass, Canada wildrye and Indiangrass. Native trees on the bottom lands were eastern cottonwood, white willow, green ash, and maple (Da Moude et al., 1975; Greenawalt and McKinzie, 1964).

Cuming County is located in the northern part of the rolling hills topographic region of Nebraska. This area of the state is characterized by long slopes, rolling hills, and broad, low gradient valleys. Elevation ranges from 383 meters in the southern part of the county to 480 meters in the northwestern part. The topography of Saunders County ranges from nearly level to very steeply sloping and bluff-like. The slopes average from 4 to 9% gradient and are 60 to 240 meters long (Elder et al., 1965). Two distinct, topographic areas exist in Washington County: (1) the bottom-lands along the Missouri and Elkhorn Rivers and (2) the uplands between the two rivers. A thorough discussion on the physiography, relief, and drainage is given by Greenawalt and McKinzie (1964).

The majority of the soils in these counties have formed in Wisconsin loess, and because the loess material on the nearly level to sloping uplands has been in place since the last glaciation, most of the soils formed between 8,000 and 10,000 years ago (Greenawalt and McKinzie, 1964).

FIELD INVESTIGATIONS

The majority of the Colo soil profiles studied were collected at the type location for the Colo series in the county soil survey. Other profiles were collected in areas where the Colo soil was delineated.

Forty-seven soil profiles were described and sampled to determine some physical, chemical, and mineralogical properties of the Colo soil series as mapped in the North Central Region. Four soil profiles were collected in Nebraska and Missouri. Two soil profiles were collected in Illinois and Minnesota. The remainder of the soil profiles were collected in Iowa (Figure 1). Descriptions and the results of the laboratory analyses are in the Appendices.

Soil samples were collected using either a 2-inch diameter soil probe or a Giddings hydraulic soil coring machine. Most of the profiles were described and sampled in the field to a depth of 152 cm. Other profiles were placed in core boxes, transported to the laboratory, and described and sampled at a later date. Horizons were subdivided into subsamples if the thickness of the horizon was greater than 25 cm. Selected profiles were sampled in 5-cm increments to approximately 110 cm. Soil samples to be analyzed by the Iowa Soil Testing Laboratory were kept moist and refrigerated.

LABORATORY PROCEDURES

The soil samples collected were air dried (except those for the Soil Testing Laboratory) and then ground to pass a 2-mm sieve. A mechanical grinder was used. A portion of the total sample was fine ground to pass a 60-mesh sieve for the total phosphorus, inorganic phosphorus, and total carbon analyses.

Particle-Size Analysis

A modified pipette method (Kilmer and Alexander, 1949) used by the Iowa Soil Survey Laboratory (Walter et al., 1978) was performed to determine particle-size. An aliquot of about 50 ml from the particle-size procedure was stored in a plastic bottle and saved for clay mineralogy and total potassium analyses.

Total Carbon

All samples analyzed for carbon were noncalcareous. Therefore, the total carbon content is equal to the amount of organic carbon in the samples. Total carbon was determined for all profiles to approximately 100 cm from a sample weighing about .25 grams or less. The samples were analyzed by a Leco automatic 70-second carbon analyzer according to the procedure described by Tabatabai and Bremner (1970).

Hydrogen Ion Activity (pH)

Hydrogen ion activity was determined using a 1:1 soil to water ratio. A Corning Combination Electrode and a Beckman Zeromatic pH meter were used.

Available Phosphorus

Available phosphorus was determined using the procedure of Bray and Kurtz (1945) and modified by Miller (1974). This procedure is known as the Bray I method.

Total Phosphorus

The amount of total phosphorus in the soil samples was determined using the procedure developed by Dick and Tabatabai (1977) and modified by Walter (Neil Walter, Department of Agronomy, Iowa State University, personal communication) and Collins (1977).

Inorganic Phosphorus

Inorganic phosphorus was determined using a modified method for determining organic phosphorus by Legg and Black (1955).

An air-dried sample weighing 1.00 grams and ground to pass a 60-mesh sieve was placed in a glass centrifuge tube. Ten ml of concentrated HCl were added and each sample was swirled gently for a few minutes. The tubes were placed in a steam bath for 10 minutes. The final temperature of the solution in the tubes was approximately 70°C. The tubes were removed from the steam bath, an additional 10 ml of concentrated HCl were added, mixed well, and then allowed to stand at room temperature for 1 hour. Distilled water (approximately 10 ml) was added to each sample, mixed well, and centrifuged at 3,000 rpm for 10 minutes. The solution was transferred to a 100-ml volumetric flask. Approximately 30 ml of distilled water were added to each tube, stoppered, mixed well, and centrifuged at 3,000 rpm for an additional 10 minutes. This solution was poured into the corresponding 100-ml volumetric flask and brought to volume with distilled water. A 2-ml aliquot was pipetted from each tube into a 25-ml volumetric flask and 4 ml of ascorbic acid solution were added. Each solution was brought to volume with distilled water. The flasks were stoppered and the contents mixed. The Spec 20 was adjusted to a wavelength of 720 nm. After 30 minutes, the % transmittance of the molybdenum blue color was read on the Bausch and Lomb Spectronic 20 spectrophotometer.

A calibration graph was plotted on semilog paper according to the results given with the standard of 0, 5, 10, 15, 20, and 25 µg phosphorus. Inorganic phosphorus in ppm was determined using the equation:

$$IP_{ppm} = \frac{(\text{reading from graph } (\mu g))\ (100\ ml)}{(\text{wt. of sample } (g))(2\ ml)}$$

Organic Phosphorus

The amount of organic phosphorus was determined by subtracting the amount of total phosphorus from the amount of inorganic phosphorus in the samples. Therefore, the organic phosphorus content was determined by difference.

Total Potassium

Total potassium content in the soil samples was determined using the procedure developed by Jackson (1958) and modified by Scott (A. D. Scott, Department of Agronomy, Iowa State University, personal communication).

A 50-ml aliquot collected from the particle-size analysis procedure was stored in a plastic bottle. Approximately 25 ml were poured into a weighed approximately 30 ml platinum crucible. Depending on the known amount of clay and the known amount of Calgon in the solution, more or less than 25 ml were needed to have about .1000 g sample. Knowing the exact amount is more important than having exactly .1000-g sample. The crucibles were placed in an oven at 105°C overnight, cooled, and weighed. Subtracting the known weight of the crucible and Calgon from the oven-dried crucible gave the weight of the <.002 mm clay fraction. A few drops of distilled water were added to wet the samples. Half a ml of $HClO_4$ and 5 ml of HF 48% were added to each crucible and then heated overnight on a sandbath at 87°C in a $HClO_4$ hood. In the morning, the sandbath temperature was raised to 110°C for 2 hours. The temperature was then raised to 160°C until the solution was dry and finally to 230°C to remove the florine. The samples were removed and cooled. Five ml of 6 N HCl and distilled water were added until the crucibles were two-thirds full. The crucibles were again placed on the sand-bath (160°C) to bring the remaining particles into solution. After the residue was completely dissolved, the samples were removed, cooled and transferred to a 100-ml volumetric flask. Distilled water was added to bring to volume.

A 3-ml aliquot of the 100 ml solution was pipetted into a 25-ml volumetric flask and 2.5 ml of 10,000 ppm Na solution were added. Distilled water was added to bring to volume.

Total potassium was determined using a Perkin-Elmer Model 303 Atomic Absorption Spectrophotometer.

Clay Mineralogy

Clay mineralogy of the <.002 mm particles was determined on selected horizons of some Colo profiles. The 50-ml aliquot stored for total potassium was also used for the clay mineralogy analysis. The plastic bottles were shaken and aliquots were placed on porcelain tile plates which were under suction. Enough suspension was added to produce a uniform layer of clay that completely covered the plates. The samples were air-dried and x-rayed. A 10% $MgCl_2$ solution in ethylene glycol was added dropwise to each sample while under suction. The samples were allowed to air-dry and then x-rayed. Each sample was heated to approximately 300°C in a muffle furnace, and placed in a desiccator.

Some of the samples were x-rayed by a General Electric diffractometer owned by the Agronomy Department, Iowa State University. Copper radiation and a nickel filter were used in this x-ray unit. Other specifications included a scanning speed of 2°/minute and chart speed of 5 cm/minute. Because of the disproportionate peak heights, peaks in the 2 to 10° range were determined at 5,000 cps and peaks in the 10 to 32° range were determined at 2,000 cps.

Other samples were x-rayed by a Picker x-ray diffractometer which was controlled by a Scientific Data System (SDS) 910 computer. The output of the SDS-910 computer, the degrees two theta and counts per second, were given by programming a Digital PDP-15 computer using Basic Computer Language. This equipment is owned and operated by the United States Department of Energy, Ames Laboratory, Iowa State University. The author would like to thank James Benson, Ames Laboratory, for permission to use the equipment.

This x-ray unit had molybdenum tube as the radiating source and a monochromatic filter. Other specifications included a scanning speed of .05°/1.5 seconds and a chart speed of approximately 2 cm/min. Because of the shorter wavelength of molybdenum radiation as compared to copper, peaks were determined from 1.50 to 17.00° for untreated and glycolated tile mounts and 1.50 to 10.00° for heated samples at 3,000 cps for all treatments.

The printout of the SDS-910 computer was used as the data source for statistical analysis and to plot the clay mineral peaks.

Soil Testing Data

Soil samples from selected Colo profiles were kept refrigerated in field-moist conditions and later analyzed for soil pH, soil buffer pH, available phosphorus, and available potassium by the Iowa State University Soil Testing Laboratory (Appendix B). Chemical procedures used by the Soil Testing Laboratory are described in an unpublished paper by Dr. K. Eik, Soil Testing Laboratory, Iowa State University, 1968.

RESULTS AND DISCUSSION

Forty-seven soil profiles were described and sampled to determine some physical, chemical, mineralogical, and morphological properties of the Colo soil series as mapped in the NCR. Laboratory data obtained included particle size distribution, hydrogen ion activity (pH), available phosphorus, total phosphorus, inorganic phosphorus, organic phosphorus, total carbon, total potassium, clay mineralogy and soil chemical information determined by the Iowa Soil Testing Laboratory.

The results from those analyses were statistically studied. The statistical analyses included determining the means, minimum values, maximum values,and weighted averages. Also, simple correlation coefficients were determined and from the correlation results, multiple linear regression models were developed. The soil sample data were statistically analyzed using the following groupings: (a) all samples from the 47 profiles (All Profiles), (b) by state (but only out-of-state samples), (c) by soil association area in Iowa, (d) as individual soil profiles.

Depth distributions of selected chemical properties and particle-size are shown graphically by soil association groups and by state groups.

Statistical Analyses of Physical and Chemical Properties for All Profiles

Profiles representing the Colo soil series as mapped in the NCR were selected to study the influence of environmental factors and soil processes on soil development. This section will discuss statistical analyses of some physical and chemical properties in all Colo soils sampled (All Profiles) in this study.

Means, minimum values, maximum values, and weighted averages for laboratory analyses of All Profiles were determined and are presented in Table 5. The weighted average was calculated for each variable by the following equation:

$$\frac{\Sigma(\text{LA x WGTPT})}{\Sigma\text{WGTPT}}$$

where Σ(LA x WGTPT) is the laboratory analysis result (LA) multiplied by the weighted point (WGTPT), and summed, and ΣWGTPT the summation of the weighted points. The weighted point is the horizon thickness in cm sampled or if the horizon was subdivided then it is the thickness of the subsample.

The mean, minimum value, maximum value, and weighted average for clay, silt, sand, TC and TK were determined using all the samples of the soil profile. The values in Table 5 for AVP, TP, IP, OP, OC/OP, OP/TP, HION, STAVP, STAVK, STHION, and STBHION were calculated omitting the first sample of the soil profile. Identification of the variables are in Appendix B.

Multiple linear regression analysis was used to provide

Table 5. Mean, minimum value, maximum value and weighted average for selected laboratory analyses; All Profiles

Laboratory analysis	Mean	Minimum value	Maximum value	Weighted average[a]
Clay[b]	32.4	16.7	49.9	30.4
Silt[b]	59.2	28.5	73.9	55.2
Sand[b]	8.4	.6	51.8	8.1
TC[b]	1.7	.0	5.0	1.6
AVP[c]	22	.0	88.0	22
TP[c]	527	188	1045	517
IP[c]	314	63	850	312
OP[c]	213	7	795	205
OC/OP	71	6	419	69
OP/TP	41	2	84	41
HION[d]	6.4×10^{-7}	1.0×10^{-8}	6.3×10^{-6}	6.0×10^{-7}
TK[b]	1.3	.7	2.1	1.3
STAVP[c]	20	2	91	18
STAVK[c]	32	9	226	29
STHION[d]	2.7×10^{-7}	1.6×10^{-8}	2.0×10^{-6}	2.0×10^{-7}
STBHION[d]	9.0×10^{-8}	2.0×10^{-8}	6.0×10^{-7}	8.6×10^{-8}

[a]In units.

[b]In %.

[c]ppm.

[d]Moles/liter.

estimates of the effects of many observations on selected variables. The computations were performed according to the multiple regression model:

$$Y_i = B_0 + B_1 X_{1i} + B_2X_{2i} + \ldots B_pX_{pi} + \epsilon_i$$

where Y_i is the dependent variable, the explanatory factors $X_1, X_2, X_3 \ldots X_p$ which are assumed to be independent, ϵ_i which is the error term because the independent explanatory factors do not completely explain the dependent variable, and the parameters $B_0, B_1, \ldots B_p$ which are the population regression coefficients (Salih, 1979; Pena-Olvera, 1979; Henao, 1976).

Pena-Olvera (1979) studied the effect of intercorrelations among soil variables in multiple regression analyses. Based on the results of his research, multiple linear regression analyses were done with variables which had < ±.60 simple correlation coefficients. This was the first stage of the statistical analyses in this study. Laboratory analyses variables included in the simple correlation analysis are listed in Table 6. Simple correlation coefficients > ±.20 for laboratory analyses for all profiles are presented in Table 7.

The highest correlation coefficient was .89 between STHION and STBHION soil variables. A moderately high correlation occurred between AVP and TP (r = .48) while a moderately low correlation occurred between STAVP and STHION (.27) and STAVP and STBHION (.27). Other investigators (Collins, 1977; Kuehl, 1978; Miller, 1974; Runge, 1963; Tembhare, 1973) noted

Table 6. Laboratory analyses variables included in the simple correlation analyses

X_i	Variable	X_i	Variable
1	Sand	9	OC/OP
2	Silt	10	OP/TP
3	Clay	11	HION
4	TC	12	TK
5	AVP	13	STAVP
6	TP	14	STAVK
7	IP	15	STHION
8	OP	16	STBHION

relationship between soil pH and available phosphorus levels. Salih's (1979) results indicated a moderately high correlation (r = -.41 to -.56) of available phosphorus level in all zones except the 30-51 cm zone versus PH2 (pH in 76-107 cm zone), PH3 (25-127 cm zone) and PH4 (in minimum soil test phosphorus zone with mean depth in profile of 70 cm). Birchett (1974) found that subsoil phosphorus levels of the horizons >60 cm deep were highly correlated with the corresponding pH levels. The simple correlation coefficients reported in this present study included samples from 0 to approximately 152 cm. Therefore, surface samples (0-60 cm) were included and direct comparison with Salih's or Birchett's results was not possible.

The variables TC and OP were also highly correlated

Table 7. Simple correlation coefficients greater than ±.20 for laboratory analyses; All Profiles

Between variables		r	No.[a]	Between variables		r	No.
Sand and	silt	-.80	377	OC/OP and	OP/TP	-.30	365
	clay	-.46	377		TK	.30	52
TC and	TP	.58	374	TK and	STAVK	-.30	46
	OP	.73	371		STHION	.21	46
	OC/OP	.22	367				
	OP/TP	.42	368	STAVP and	STAVK	.51	296
					STHION	.27	296
AVP and	TP	.48	475		STBHION	.27	296
	IP	.53	472				
	OC/OP	.24	468	STAVK and	STHION	.47	296
	HION	.36	488		STBHION	.60	296
TP and	IP	.67	480	STHION and	STBHION	.89	296
	OP	.62	479				
IP and	OC/OP	.24	367				
	OP/TP	-.69	476				
OP and	OC/OP	-.26	367				
	OP/TP	.74	476				

[a]Number of samples.

(r = .73). In most Colo soil profiles: (1) total carbon content can be used in calculating the amount of organic matter in the soil. Organic phosphorus is a component of organic matter. Therefore, there should be a relationship between the two variables. (2) Both TC and OP decrease with increasing depth in the profile.

The second stage of the statistical analysis was to model linear functions of selected variables in a multiple regression equation. The fitting of the multiple regression equation was done by using the computer program PROC STEPWISE (Barr et al., 1976). The multiple regression equations and R^2 values for All Profiles are given in Table 8. The soil laboratory data were analyzed by this procedure to a depth of approximately 100 cm. This is the approximate maximum depth to which TC was determined.

Soil Groups According to Principal Soil Association Areas in Iowa

The Colo soil profiles sampled in Iowa for this regional research project were grouped according to principal soil association areas in Iowa (Oschwald et al., 1965). For example, Plymouth, O'Brien, Cherokee, and parts of Clay and Sac counties are in the Galva-Primghar-Sac soil association area (Figure 16). Therefore, the samples from the profiles collected in these counties were combined and will be referred to as the GPS group. Other groups are listed in Table 9. Listings of groups for Colo soil profiles outside of Iowa are presented in Table 10.

Particle-size results

The range in clay contents (<.002 mm) of All Profiles was from 16.7% to 49.9% with a mean of 32.4% and a weighted average of 30.4% (Table 5). The lowest mean and weighted averages were calculated in the FDS group, 27.8% and 27.7% respectively. The highest mean and weighted average were

Table 8. Multiple regression equations and R^2 values[a] for selected laboratory analyses on All Profiles

Y	Regression equation[b]	R^2
Sand	29.981 - .587CLAY - .029AVP - .005IP - 927021.022HION	.24
Silt	69.710 - .406CLAY + .029AVP + .005IP + 974156.360HION	.15
TC	- .526 + .006TP - .006IP - .005OP/TP + .012OC/OP	.72
AVP	-10.476 - 1.981TC + .033TP + .047IP + 6321934.339HION	.47
TP	516.7 - .878SAND + 144.88TC + 3.484AVP - 1.491OC/OP - 3.484OP/TP - 13254587.347HION	.65
OP	162.274 + .909SILT + 3.043CLAY + 1.636AVP - .153IP - .695OC/OP	.12
OC/OP	138.5 - .517SILT + 36.744TC - 1.375TP + 1.332IP + 1.183OP - .756OP/TP - 1249998.355HION	.73
HION	$9.6x10^{-7}$ - $2.0x10^{-8}$SAND + $3.0x10^{-8}$AVP - $.0x10^{-8}$IP[c]	.22

[a]All are significant at 1% level.

[b]276 samples.

[c]Number too small for computer to print out.

Figure 16. Principal soil association areas in Iowa

Mo:	Moody	GH:	Grundy-Haig
GPS:	Galva-Primghar-Sac	OMT:	Otley-Mahaska-Taintor
LOS:	Luton-Onawa-Salix	B:	Soils of Mississippi River Bottomlands
MIH:	Monona-Ida-Hamburg	TM:	Tama-Muscatine
M:	Marshall	F:	Fayette
SSM:	Shelby-Sharpsburg-Macksburg	DT:	Dinsdale-Tama
AGH:	Adair-Grundy-Haig	KFC:	Kenyon-Floyd-Clyde
ASE:	Adair-Seymour-Edina	CLC:	Cresco-Lourdes-Clyde
CNW:	Clarion-Nicollet-Webster	FDS:	Fayette-Dubuque-Stonyland
CKL:	Clinton-Keswick-Lindley	D:	Downs
L:	Lindley-Keswick-Weller		

——— Abrupt boundary ••• Gradual boundary - - - Tentative boundary

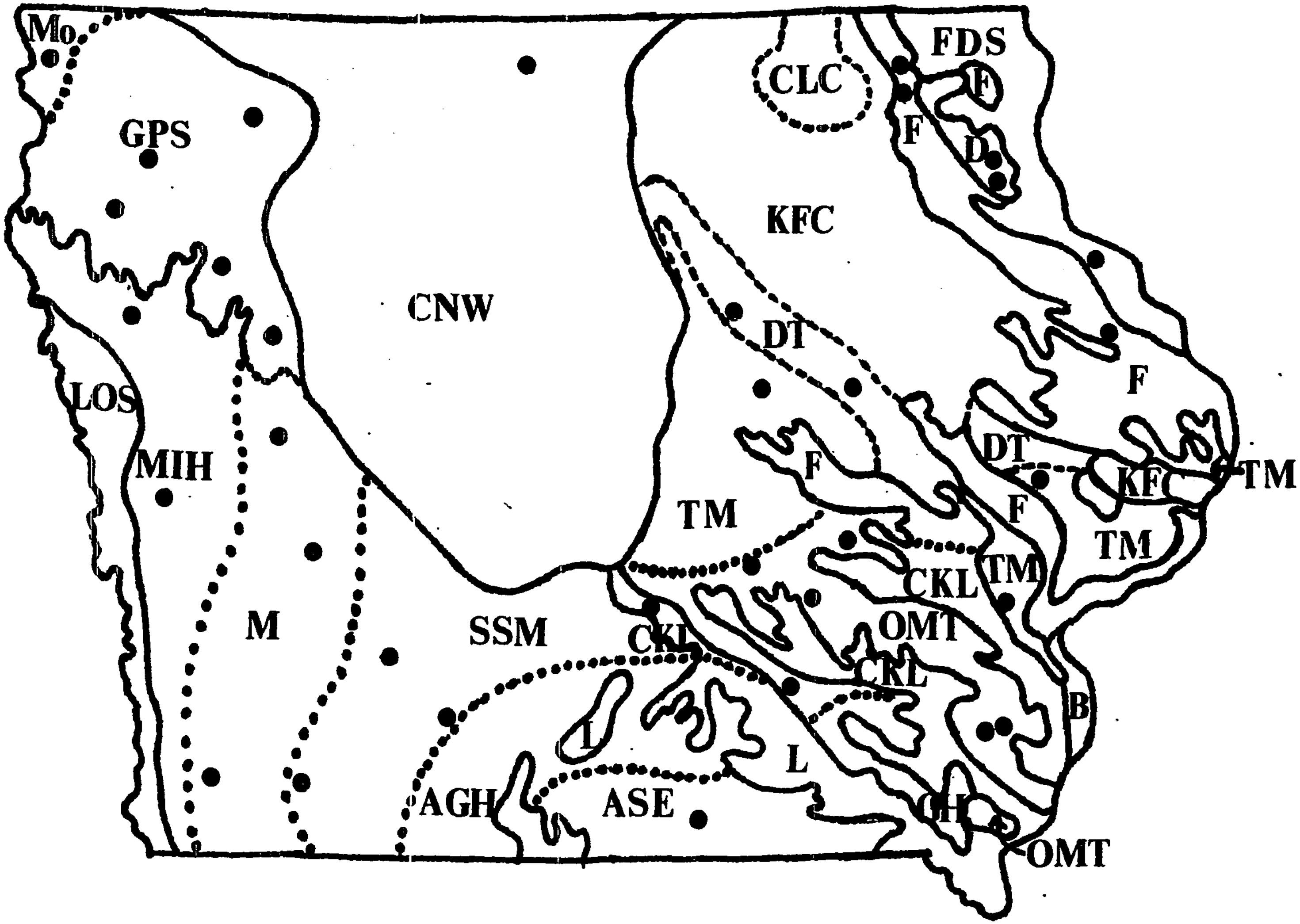

Mo
GPS
CNW
CLC
FDS
F
F
D
KFC
DT
F
LOS
MIH
F
DT
TM
KFC
TM
F
TM
TM
CKL
M
SSM
OMT
CKL
CKL
B
L
L
AGH
ASE
OH
OMT

Table 9. Iowa soil associations, county(ies) within the association, and Colo grouping

Iowa soil association area	County name(s)	Soil no.[a]	Colo grouping
Marshall	Audubon	5	M
	Crawford	24	
	Fremont	36	
Monona-Ida-Hamburg	Woodbury	97	MIH
	Harrison	43	
Shelby-Sharpsburg-Macksburg	Adair	1	SSM
	Page	75	
	Union	88	
Clinton-Keswick-Lindley	Marion	63	CKL
Moody	Lyon	60	Mo
Galva-Primghar-Sac	Plymouth	75	GPS
	O'Brien	71	
	Cherokee	18	
	Clay	21	
	Sac	81	
Clarion-Nicollet-Webster	Winnebago	95	CNW
Adair-Seymour-Edina	Appanoose	4	ASE
Otley-Mahaska-Taintor	Mahaska	62	OMT
	Poweshiek	79	
	Keokuk	48	
	Iowa	54	
	Henry	44	
	Des Moines	29	
Grundy-Haig	Lee	56	GH
Fayette	Winneshiek	96-1,2	F
	Dubuque	31-2	
Fayette-Dubuque-Stonyland	Dubuque	31-1	FDS
Downs	Clayton	22-1,2	D
Dinsdale-Tama	Grundy	38	DT
	Benton	6	
Tama-Muscatine	Tama	86	TM
	Cedar	16	
	Johnson	52	

[a]No. refers to Colo soil sampled.

Table 10. Listing of soil groups outside of Iowa

State	County Name	County Soil no.	Grouping
Nebraska	Stanton	N1	NE
	Cuming	N2	
	Washington	N3	
	Saunders	N4	
Missouri	Harrison	M1	MISSO
	Lafayette	M2	
	Caldwell	M3	
	Scotland	M4	
Illinois	Logan	I	ILL
	Champaign	I2	
Minnesota	Waseca	MINN1	MINN
	Dakota	MINN2	

38.8% and 38.7%, respectively, in the MINN group (Table 11).

The depth distribution of clay in soil profiles has been studied primarily in soils on relatively stable landscape positions (Smith et al., 1950; McKim, 1972; White and Riecken, 1955; Corliss, 1958; Ryan, 1959). Recently, the clay depth distribution has been investigated in soils on relatively less stable landscape positions (Collins, 1977; Kuehl, 1978; Oparaugo, 1979; Coleman, 1980). Clay depth distribution in soils formed in alluvial material has not received as much attention. Therefore, regional trends of the amount of clay in alluvial derived soils will be discussed.

Table 11. Means, minimum values, maximum values, and weighted averages of laboratory analyses by groups

Laboratory analyses	Mean	Minimum value	Maximum value	Weighted average[a]
<u>Mo group</u>				
Clay[b]	30.1	23.6	35.8	30.0
Silt[b]	65.5	60.6	72.2	65.6
Sand[b]	4.4	3.6	5.9	4.5
TC[b]	1.5	.8	3.0	1.6
AVP[c]	26	8	40	26
TP[c]	595	448	924	582
IP[c]	273	100	450	289
OP[c]	322	165	674	293
OC/OP	39	27	63	41
OP/TP	53	27	82	50
HION[c]	$3.4x10^{-7}$	$5.0x10^{-8}$	$1.6x10^{-6}$	$2.0x10^{-7}$
TK[b]	1.1	.7	1.3	1.1
STAVP[c]	14	2	40	13
STAVK[c]	45	33	73	44
SHION[d]	$1.2x10^{-7}$	$1.0x10^{-8}$	$6.0x10^{-7}$	$9.4x10^{-8}$
STBHION[d]	$7.0x10^{-8}$	$2.0x10^{-8}$	$2.0x10^{-7}$	$5.5x10^{-8}$

[a]Weighted averages for clay, silt, and sand were determined to the maximum depth analyzed, in most profiles 152 cm. TK weighted average determined by total cm of the samples analyzed. TC weighted average determined to approximately 100 cm. Weighted averages for other analyses were determined without the first sample to the maximum depth analyzed, in most profiles 152 cm.

[b]%.

[c]ppm.

[d]Moles/liter.

Table 11. (Continued)

Laboratory analyses	Mean	Minimum value	Maximum value	Weighted average
GPS group				
Clay	34.0	19.7	39.5	34.1
Silt	56.2	28.5	64.4	56.2
Sand	9.9	1.3	51.8	9.8
TC	1.9	.5	5.0	2.0
AVP	9	.0	39	9
TP	444	262	709	438
IP	251	100	550	249
OP	197	9	422	189
OC/OP	73	27	115	73
OP/TP	43	2	70	43
HION	2.2×10^{-7}	1.0×10^{-8}	2.0×10^{-6}	2.0×10^{-7}
STAVP	7	2	16	7
STAVK	24	16	35	23
STHION	1.4×10^{-7}	6.3×10^{-9}	5.0×10^{-7}	1.0×10^{-7}
STBHION	7.0×10^{-8}	2.0×10^{-8}	2.0×10^{-7}	7.4×10^{-8}
MIH group				
Clay	34.2	31.6	35.8	34.4
Silt	63.0	60.6	66.6	62.9
Sand	2.8	1.8	5.4	2.7
TC	1.7	.7	2.9	1.8
AVP	49	28	78	48
TP	699	562	825	694
IP	512	325	700	509
OP	192	44	375	185
OC/OP	31	6	79	34
OP/TP	74	27	92	75
HION	1.8×10^{-6}	6.3×10^{-7}	6.3×10^{-6}	1.8×10^{-6}
TK	1.4	1.1	1.7	1.4
STAVP	38	21	60	36
STAVK	48	23	100	51
STHION	2.0×10^{-7}	1.0×10^{-7}	5.0×10^{-7}	2.0×10^{-7}
STBHION	1.0×10^{-7}	4.0×10^{-8}	1.0×10^{-7}	7.5×10^{-8}
M group				
Clay	33.7	30.0	38.0	32.4
Silt	61.7	52.2	72.2	57.1
Sand	4.6	2.2	9.8	4.8
TC	1.3	.3	2.4	1.4
AVP	31	17	58	26
TP	538	404	792	453

Table 11. (Continued)

Laboratory analyses	Mean	Minimum value	Maximum value	Weighted average
IP	328	88	550	292
OP	210	30	448	161
OC/OP	58	6	125	49
OP/TP	39	9	84	31
HION	6.0×10^{-7}	1.0×10^{-7}	3.2×10^{-6}	6.0×10^{-7}
TK	1.3	1.1	1.6	1.5
STAVP	26	17	73	26
STAVK	38	26	106	37
STHION	9.6×10^{-8}	4.0×10^{-8}	3.0×10^{-7}	1.1×10^{-7}
STBHION	5.0×10^{-8}	3.0×10^{-8}	1.0×10^{-7}	5.9×10^{-8}
<u>SSM group</u>				
Clay	34.8	30.2	43.2	36.2
Silt	61.1	50.4	66.8	59.7
Sand	4.1	.9	8.2	4.1
TC	1.3	.1	2.9	1.4
AVP	33	10	57	32
TP	504	373	784	497
IP	318	88	463	311
OP	196	38	521	186
OC/OP	92	31	419	89
OP/TP	39	8	76	39
HION	1.3×10^{-6}	1.0×10^{-7}	2.5×10^{-6}	1.2×10^{-6}
TK	1.4	1.3	1.6	1.5
STAVP	19	7	30	19
STAVK	22	13	35	22
STHION	5.5×10^{-7}	2.0×10^{-8}	1.6×10^{-6}	5.0×10^{-7}
STBHION	1.1×10^{-7}	3.0×10^{-8}	3.0×10^{-7}	1.0×10^{-7}
<u>ASE group</u>				
Clay	30.3	24.9	35.1	28.3
Silt	55.1	51.1	60.8	51.2
Sand	14.6	10.1	23.3	13.4
TC	1.4	.5	2.5	1.4
AVP	20	15	38	20
TP	684	441	900	698
IP	474	375	525	484
OP	220	42	425	214
OC/OP	51	37	68	37
OP/TP	29	7	42	38
HION	7.0×10^{-8}	3.0×10^{-8}	2.0×10^{-7}	6.5×10^{-8}

Table 11. (Continued)

Laboratory analyses	Mean	Minimum value	Maximum value	Weighted average
CKL group				
Clay	29.3	23.6	31.7	29.7
Silt	65.1	62.1	66.9	65.5
SAND	5.7	2.0	14.4	4.8
TC	.9	.5	1.2	.8
AVP	16	8	24	16
TP	310	262	373	299
IP	197	125	263	190
OP	113	74	156	109
OC/OP	69	49	88	64
OP/TP	37	24	52	35
HION	$2.1x10^{-7}$	$1.3x10^{-7}$	$3.2x10^{-7}$	$1.0x10^{-7}$
TK	1.5	1.2	1.9	1.4
STAVP	12	6	23	11
STAVK	29	17	64	28
STHION	$9.1x10^{-8}$	$5.0x10^{-8}$	$1.6x10^{-7}$	$8.5x10^{-8}$
STBHION	$4.0x10^{-8}$	$3.0x10^{-8}$	$6.0x10^{-8}$	$4.2x10^{-8}$
OMT group				
Clay	32.1	24.8	39.1	31.5
Silt	57.8	35.5	72.6	56.7
Sand	10.1	.6	29.9	10.1
TC	1.9	.6	3.3	1.8
AVP	21	2	78	21
TP	451	205	796	452
IP	239	75	625	242
OP	214	52	492	210
OC/OP	65	38	101	64
OP/TP	48	17	80	48
HION	$6.7x10^{-7}$	$1.3x10^{-7}$	$2.0x10^{-6}$	$6.1x10^{-7}$
TK	1.6	1.4	1.9	1.6
STAVP	26	9	91	26
STAVK	33	9	133	32
STHION	$9.0x10^{-8}$	$2.0x10^{-8}$	$3.0x10^{-7}$	$7.4x10^{-8}$
STBHION	$6.0x10^{-8}$	$3.0x10^{-8}$	$2.0x10^{-7}$	$7.4x10^{-8}$
GH group				
Clay	32.4	29.2	36.4	32.5
Silt	63.6	61.6	67.7	63.4
Sand	4.0	2.0	8.8	4.2
TC	1.3	0	2.6	1.3
AVP	8	3	18	8
TP	393	300	528	387

Table 11. (Continued)

Laboratory analyses	Mean	Minimum value	Maximum value	Weighted average
IP	223	150	338	224
OP	170	72	378	163
OC/OP	55	10	85	57
OP/TP	42	21	72	41
HION	2.5×10^{-7}	1.0×10^{-7}	5.0×10^{-7}	2.0×10^{-7}
TK	1.4	1.2	1.5	1.4
STAVP	9	5	22	8
STAVK	24	11	60	23
STHION	2.5×10^{-7}	4.0×10^{-8}	1.6×10^{-6}	1.0×10^{-7}
STBHION	6.0×10^{-8}	3.0×10^{-8}	2.0×10^{-7}	5.8×10^{-8}
<u>TM group</u>				
Clay	30.2	16.7	39.4	29.6
Silt	59.0	50.4	73.8	59.5
Sand	10.8	3.3	20.9	11.0
TC	1.3	0	2.8	1.3
AVP	26	6	81	28
TP	557	302	923	533
IP	343	100	800	339
OP	214	8	591	194
OC/OP	61	7	119	52
OP/TP	41	3	78	38
HION	7.2×10^{-7}	1.0×10^{-7}	2.0×10^{-6}	6.0×10^{-7}
TK	1.3	.9	1.8	1.3
STAVP	24	6	51	26
STAVK	22	12	49	22
STHION	4.1×10^{-7}	6.0×10^{-8}	1.3×10^{-6}	3.0×10^{-7}
STBHION	1.1×10^{-7}	3.0×10^{-8}	3.0×10^{-7}	1.0×10^{-7}
<u>DT group</u>				
Clay	30.3	18.5	37.3	30.7
Silt	58.3	36.0	69.8	59.2
Sand	11.4	2.1	45.5	13.4
TC	1.7	.1	3.9	1.7
AVP	15	7	35	16
TP	585	415	743	596
IP	395	175	650	412
OP	190	7	481	184
OC/OP	79	23	144	78
OP/TP	36	7	73	34
HION	6.5×10^{-7}	3.2×10^{-7}	1.6×10^{-6}	6.0×10^{-7}
STAVP	11	6	25	11
STAVK	27	23	39	26

Table 11. (Continued)

Laboratory analyses	Mean	Minimum value	Maximum value	Weighted average
STHION	$2.0x10^{-7}$	$8.0x10^{-8}$	$4.0x10^{-7}$	$1.0x10^{-7}$
STBHION	$1.0x10^{-7}$	$4.0x10^{-8}$	$2.0x10^{-7}$	$8.5x10^{-8}$
FDS group				
Clay	27.8	25.1	30.5	27.7
Silt	67.5	65.6	69.6	67.5
Sand	4.7	3.9	5.7	4.8
TC	1.5	.5	2.7	1.5
AVP	8	5	12	7
TP	263	65	375	241
IP	129	63	263	115
OP	134	61	250	126
OC/OP	76	50	89	70
OP/TP	52	20	75	48
HION	$1.5x10^{-6}$	$1.3x10^{-7}$	$2.0x10^{-6}$	$1.2x10^{-6}$
D group				
Clay	30.2	23.6	36.0	30.2
Silt	66.2	61.0	73.9	65.9
Sand	3.6	1.7	8.8	3.6
TC	2.2	.8	3.8	2.3
AVP	14	8	24	14
TP	578	389	829	577
IP	394	225	600	382
OP	192	18	511	195
OC/OP	85	59	190	84
OP/TP	32	4	67	33
HION	$3.0x10^{-7}$	$4.0x10^{-8}$	$1.3x10^{-6}$	$3.0x10^{-7}$
TK	1.6	1.4	1.8	1.6
STAVP	11	8	13	11
STAVK	47	21	213	53
STHION	$2.9x10^{-7}$	$6.0x10^{-8}$	$1.3x10^{-6}$	$3.0x10^{-7}$
STBHION	$1.3x10^{-7}$	$3.0x10^{-8}$	$6.0x10^{-7}$	$1.0x10^{-7}$
F group				
Clay	31.3	26.8	40.5	31.4
Silt	63.0	43.7	69.0	61.4
Sand	5.7	1.8	21.4	7.2
TC	2.4	1.0	4.3	2.5
AVP	25	3	56	21
TP	758	483	1045	761
IP	399	225	650	386

Table 11. (Continued)

Laboratory analyses	Mean	Minimum value	Maximum value	Weighted average
OP	358	82	795	375
OC/OP	81	36	146	75
OP/TP	45	10	76	47
HION	4.8×10^{-7}	2.0×10^{-8}	5.0×10^{-6}	3.0×10^{-7}
TK	1.4	1.1	2.1	1.4
STAVP	35	21	59	35
STAVK	60	25	226	61
STHION	4.6×10^{-7}	1.0×10^{-7}	2.0×10^{-6}	4.6×10^{-7}
STBHION	1.5×10^{-7}	6.0×10^{-8}	5.0×10^{-7}	1.5×10^{-7}
<u>CNW group</u>				
Clay	33.2	24.8	39.4	31.5
Silt	45.2	33.8	51.2	42.8
Sand	21.6	10.0	41.4	25.7
TC	2.4	1.4	3.6	2.3
AVP	17	6	37	22
TP	601	375	914	667
IP	467	275	850	550
OP	134	64	294	117
OC/OP	151	109	195	131
OP/TP	23	7	42	20
HION	4.0×10^{-8}	1.0×10^{-8}	1.0×10^{-7}	3.6×10^{-8}
TK	.9	.7	1.2	.9
STAVP	13	6	34	18
STAVK	15	11	28	18
STHION	3.0×10^{-8}	1.0×10^{-8}	4.0×10^{-8}	3.6×10^{-8}
STBHION	4.0×10^{-8}	4.0×10^{-8}	5.0×10^{-8}	3.6×10^{-8}
<u>NE group</u>				
Clay	32.6	23.6	39.8	33.1
Silt	63.0	57.3	67.3	64.8
Sand	4.4	1.0	9.1	4.7
TC	1.4	.5	2.5	1.8
AVP	34	3	88	32
TP	560	362	918	500
IP	387	138	738	355
OP	173	26	321	155
OC/OP	76	34	231	69
OP/TP	31	6	66	26
HION	8.9×10^{-7}	2.0×10^{-8}	5.0×10^{-6}	7.0×10^{-7}
TK	.8	.7	1.4	.8
STAVP	41	14	22	40
STAVK	42	7	33	41

Table 11. (Continued)

Laboratory analyses	Mean	Minimum value	Maximum value	Weighted average
STHION	6.2×10^{-7}	5.0×10^{-7}	3.0×10^{-8}	5.0×10^{-7}
STBHION	1.5×10^{-7}	1.2×10^{-7}	4.0×10^{-8}	1.0×10^{-7}
<u>MISSO group</u>				
Clay	32.7	24.3	44.8	32.7
Silt	59.4	40.1	73.1	59.7
Sand	7.9	.7	35.2	7.6
TC	1.1	.1	2.0	.8
AVP	21	2	59	19
TP	426	224	675	378
IP	233	75	400	209
OP	193	70	419	169
OC/OP	50	7	81	43
OP/TP	45	20	71	40
HION	9.9×10^{-7}	1.0×10^{-7}	3.2×10^{-6}	8.0×10^{-7}
TK	1.4	1.4	1.5	1.4
STAVP	12	6	29	11
STAVK	19	11	31	18
STHION	4.6×10^{-7}	8.0×10^{-8}	1.0×10^{-7}	1.0×10^{-7}
STBHION	1.1×10^{-7}	3.0×10^{-8}	2.0×10^{-7}	1.0×10^{-7}
<u>ILL group</u>				
Clay	28.3	25.6	33.6	28.6
Silt	54.6	45.7	70.6	54.7
Sand	17.1	1.6	26.6	17.8
TC	1.7	.9	2.5	1.5
AVP	6	3	13	5
TP	551	240	930	479
IP	186	75	325	157
OP	343	165	630	322
OC/OP	47	34	64	39
OP/TP	66	54	79	56
HION	1.9×10^{-7}	1.3×10^{-7}	4.0×10^{-7}	1.8×10^{-7}
TK	1.8	1.6	1.9	1.8
STAVP	6	3	14	7
STAVK	32	21	57	42
STHION	2.0×10^{-8}	2.0×10^{-8}	5.0×10^{-8}	2.4×10^{-8}
STBHION	5.0×10^{-8}	5.0×10^{-8}	1.0×10^{-7}	1.0×10^{-7}

Table 11. (Continued)

Laboratory analyses	Mean	Minimum value	Maximum value	Weighted average
MINN group				
Clay	38.8	24.2	49.9	38.7
Silt	51.5	46.4	69.0	51.2
Sand	9.7	1.9	27.3	10.1
TC	1.8	.1	4.5	1.8
AVP	15	5	32	12
TP	548	188	886	458
IP	323	100	668	266
OP	225	64	475	192
OC/OP	82	7	145	77
OP/TP	43	15	82	40
HION	$1.2\text{x}10^{-7}$	$5.0\text{x}10^{-8}$	$2.0\text{x}10^{-7}$	$1.1\text{x}10^{-7}$
TK	.9	.8	1.1	.9
STAVP	12	6	24	12
STAVK	20	12	47	20
STHION	$5.0\text{x}10^{-8}$	$2.0\text{x}10^{-8}$	$1.0\text{x}10^{-6}$	$4.7\text{x}10^{-8}$
STBHION	$5.0\text{x}10^{-8}$	$4.0\text{x}10^{-8}$	$1.0\text{x}10^{-6}$	$4.7\text{x}10^{-8}$

Progressing from the MIH group in western Iowa to the OMT group in southeast Iowa (Figure 16), mean and weighted averages were: MIH group 34.2% and 34.4%; M group 33.7% and 32.4%; SSM group 34.8% and 36.2%; CKL group 29.3% and 29.7; ASE group 30.3% and 28.3%; OMT group 32.1% and 31.5%; and GH group 32.4% and 32.5%, respectively. Clay contents in soils on stable upland landscape positions indicate a trend of increasing clay content with increasing distance east of the Missouri River bottomlands.

The soils on stable upland landscape positions were formed in Wisconsin-age loess. It is known that loess thickness decreases with increasing distance from the source and that the amount of clay in the subsoil increases as loess thickness decreases (Hutton, 1948; Ruhe, 1969; Worcester, 1973; Coleman, 1980). With increasing clay content in the subsoil, surface clay content usually decreases and these soil materials may contribute sediment to the drainage area. Soils which have formed on landscape positions which accumulate sediments may have similar particle-size properties as those upstream or upslope. The clay contents of the surface layer (approximately 0-15 cm) and subsoil (approximately 20-60 cm) (soil series files) of the principal upland soils in the soil association groups are presented in Table 12. The principal upland soils in the MIH group had an average clay content of 20% in the surface layer and an average of 19% in the subsoil. The clay content of the Colo soils was substantially higher indicating that (1) the source of the sediments may not have originated from local sources or associated upland soils but rather from more distant sources upstream, (2) the coarser particles were not deposited locally but were carried farther downstream, and/or (3) clay formed _in situ_. Figure 17a shows the clay depth distribution of the Colo soils in the MIH group. The possibility that clay formed in place or that clay has moved from the surface to the subsoil is remote because the clay content is uniform with depth. The clay content did not increase in the subsoil as it does in some upland soils. It is more likely that the high clay content in the Colo profiles

Table 12. Comparison of clay contents in the surface layer and subsoil and B/A clay ratios of the principal upland soils in the soil association groups

Soil	Surface[a] (%)	Subsoil[a] (%)	B/A clay ratio
<u>Mo group</u>			
Moody	31	30	
Average	31	30	1.0
<u>GPS group</u>			
Galva	36	27	
Primghar	37	27	
Sac	35	26	
Average	36	27	.75
<u>MIH group</u>			
Monona	24	21	
Ida	21	21	
Hamburg	14	14	
Average	20	19	1.0
<u>M group</u>			
Marshall	31	30	
Average	31	30	1.0
<u>SSM group</u>			
Shelby	25	34	
Sharpsburg	30	39	
Macksburg	30	39	
Average	28	37	1.3
<u>ASE group</u>			
Adair	31	44	
Seymour	25	46	
Edina	25	50	
Average	27	47	1.7

[a]Midpoint of ranges given on Form 5, official descriptions, soil survey files, Agronomy Laboratory, Iowa State University, Ames, Iowa, surfaces 0~15 cm, subsoil ~20-60 cm.

Table 12. (Continued)

Soil	Surface (%)	Subsoil (%)	B/A clay ratio
CKL group			
Clinton	21	39	
Keswick	25	42	
Lindley	23	39	
Average	23	40	1.7
OMT group			
Otley	31	38	
Mahaska	30	39	
Taintor	33	40	
Average	31	39	1.3
GH group			
Grundy	25	45	
Haig	27	45	
Average	26	45	1.7
TM group			
Tama	27	31	
Muscatine	29	32	
Average	28	32	1.1
DT group			
Dinsdale	27	32	
Tama	27	31	
Average	27	32	1.2
FDS group			
Fayette	20	32	
Dubuque	20	30	
Stonyland	-	-	
Average	20	31	1.6
D group			
Downs	21	30	
Average	21	30	1.4

Table 12. (Continued)

Soil	Surface (%)	Subsoil (%)	B/A clay ratio
F group			
Fayette	20	32	
Average	20	32	1.6
CNW group			
Clarion	21	27	
Nicollet	26	30	
Webster	31	30	
Average	26	29	1.1

of the MIH group can be attributed to sediments originating farther upstream. The Colo profiles in the MIH group were sampled on the floodplains of the East Nishnabotna River (Fremont County) and the West Fork of the Little Sioux River (Woodbury County). Both are major streams with drainage areas over 650 km^2 (Larimer, 1974) in western Iowa.

The principal upland soil in the M group had an average clay content of 31% in the surface layer and 30% in the subsoil, slightly less than the weighted average for the Colo soils in the M group. Weighted average clay content of the Colo soils in the SSM group was similar to the average clay content in the subsoil of the upland soils. Clay contents in the surface layer of the principal upland soils were similar to weighted averages of the Colo soils in ASE and OMT groups. Means and weighted averages of the groups from western Iowa to

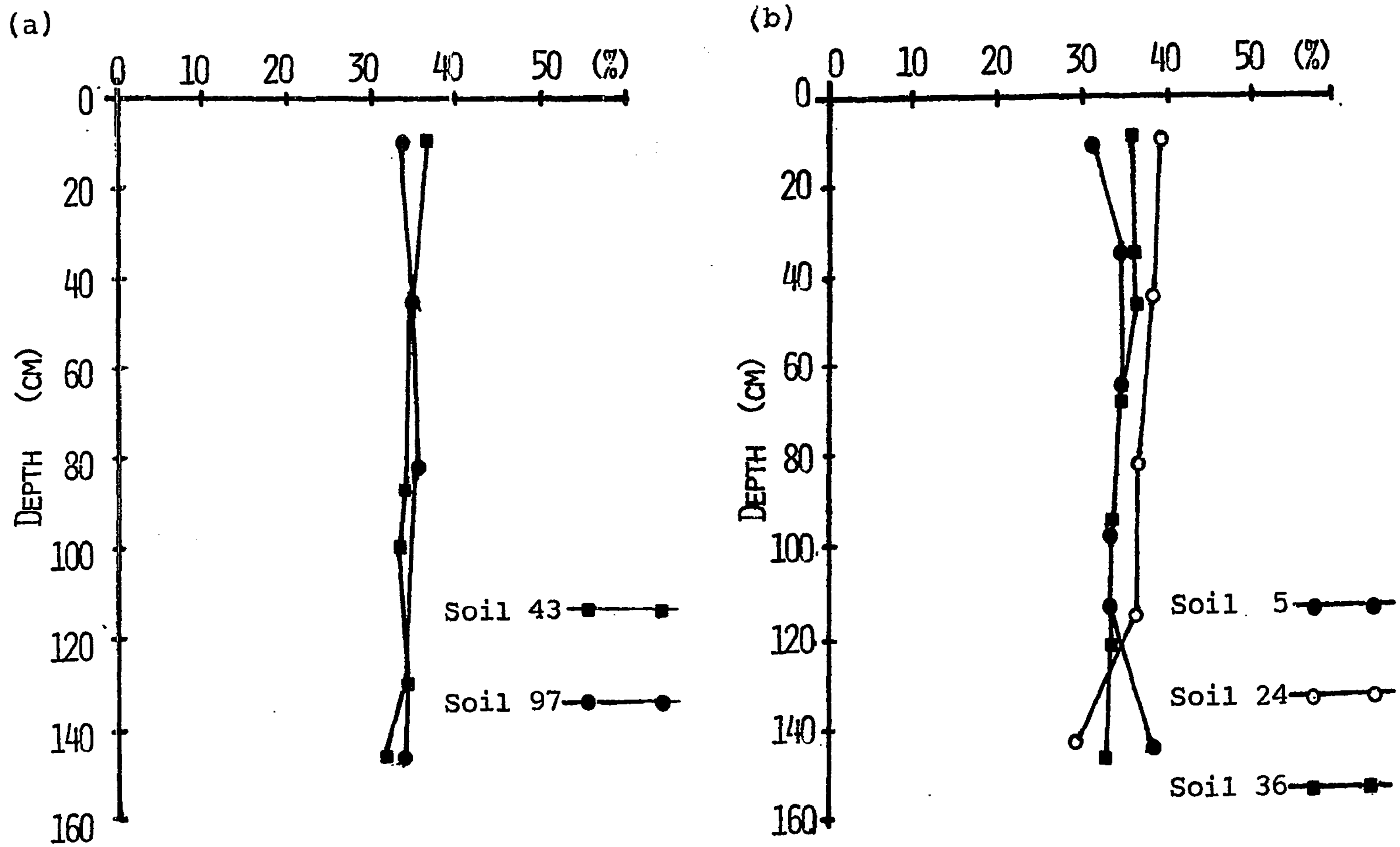


Figure 17. Clay depth distribution in Colo soils in (a) MIH group and (b) M group

southeastern Iowa do not show the trend of increasing clay content in the subsoil as do the principal upland soils. Factors influencing and related to the amount of clay in upland loess-derived soils in this area of Iowa, generally are the result of (1) distance from the source, (2) thickness of the loess, and (3) depth to more slowly permeable paleosols. These three factors seem to have had little influence on the development of many soils formed in alluvial sediments. Clay depth distributions are presented in Figures 17, 18, 19, and 20. The clay distributions in the Colo profiles for MIH, M, SSM, CKL, ASE, GH, and OMT groups have two patterns. One pattern is almost a straight line as indicated in Figure 17a. The second pattern is a curve that increases with depth to a maximum then decreases with depth as shown in Figure 20a.

An indicator of profile development and horizon differentiation has been the B/A clay ratio calculated by:

$$\frac{\text{maximum clay content in the B horizon}}{\text{minimum clay content in the A horizon}} .$$

This ratio is based on the assumption that if a soil has been stable in space and time, clay would have formed and moved from the upper layers to lower depths. Therefore, a soil with a larger B/A clay ratio is considered to be more developed than one with a smaller B/A clay ratio. In soils, a ratio of 1.0 indicates little clay eluviation or illuviation or clay formation in the soil profile. B/A clay ratios were calculated for the principal upland soils assuming the surface

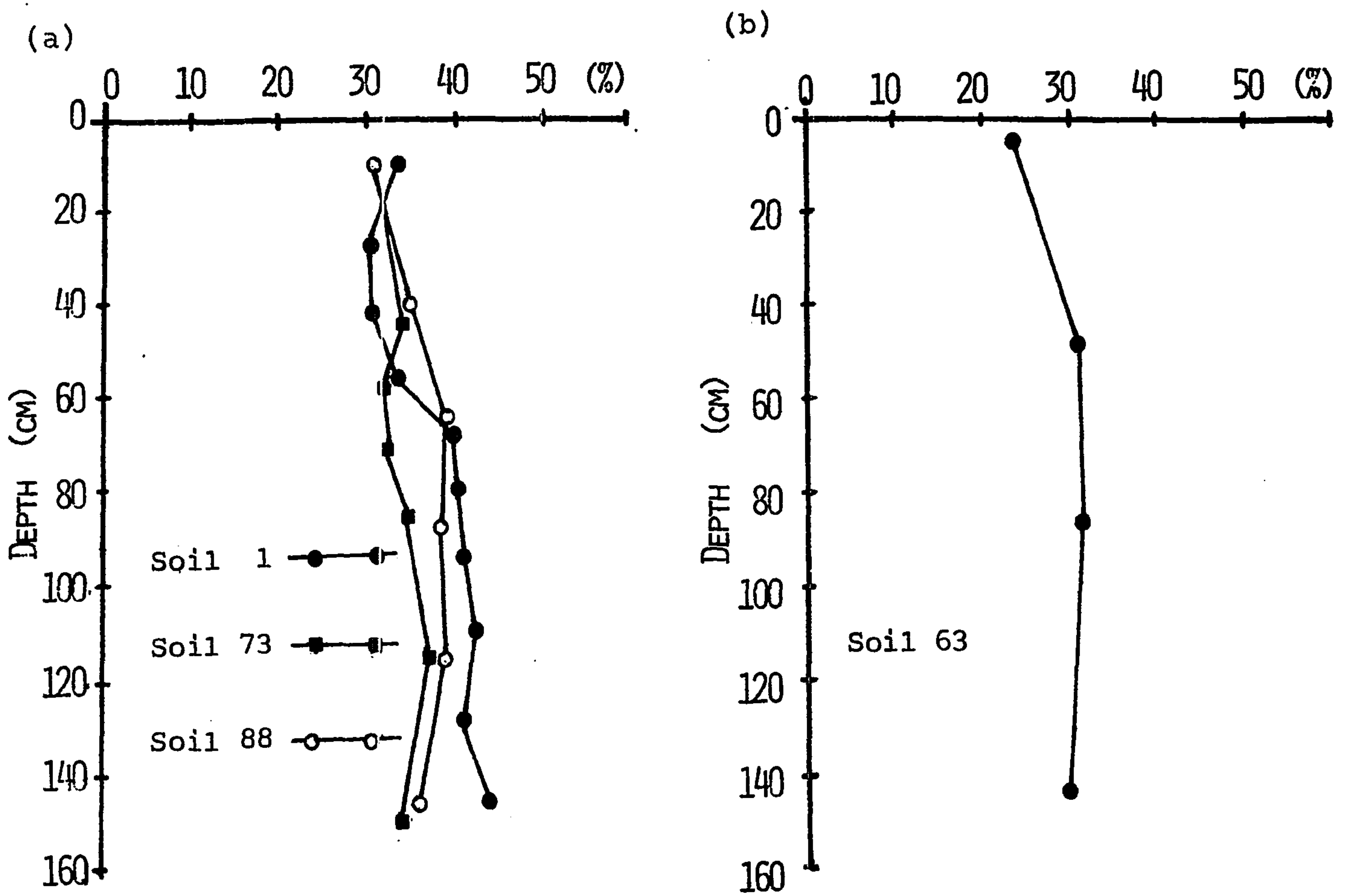


Figure 18. Clay depth distribution in Colo soils in (a) SSM group and (b) CKL group

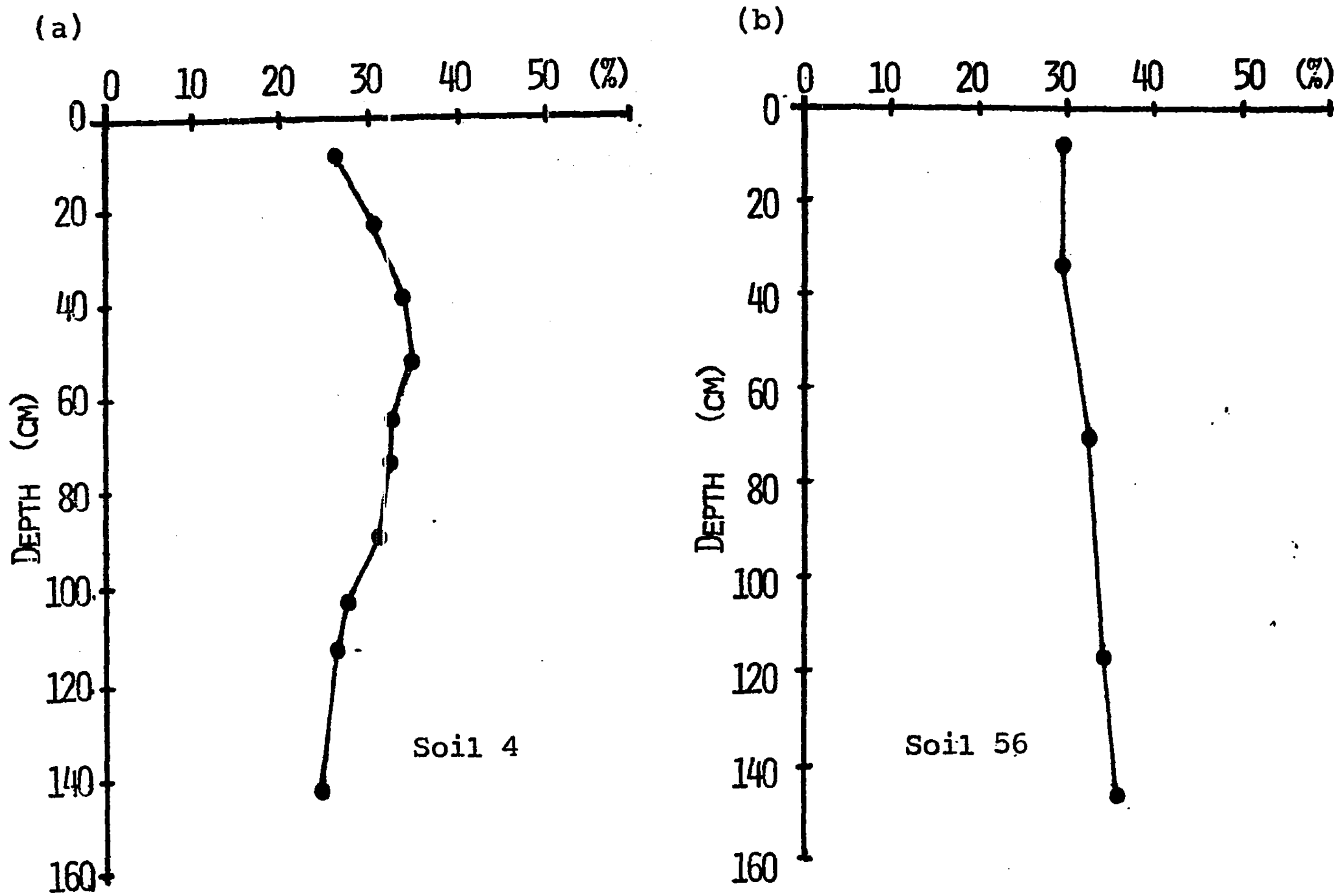


Figure 19. Clay depth distribution in Colo soils in (a) ASE group and (b) GH group

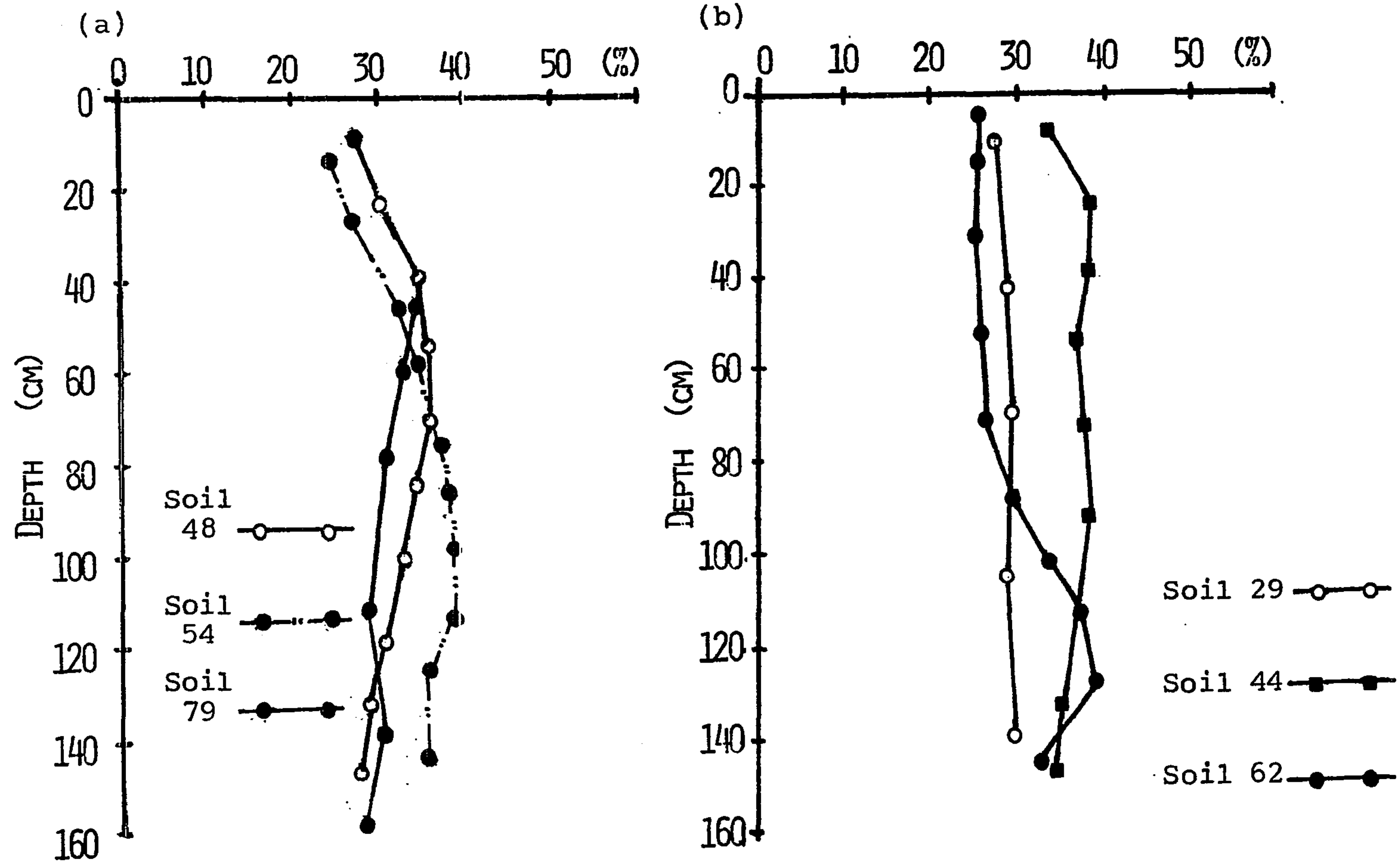


Figure 20. Clay depth distribution in Colo Soils in OMT groups

layer to be the A horizon and the subsoil to be the B horizon. A general trend of increasing B/A ratio from western Iowa to southeast Iowa does exist for the upland soils (Table 12). Ratios were also calculated for the Colo groups discussed (Table 13). Caution must be used in interpreting B/A clay ratios for soils developed in alluvial sediments because (1) the sediments could be texturally stratified and (2) a layer of overwash, low in clay or high in silt, may exist in the A horizon. Visible particle-size stratification was not noted during sampling and is not evident in the data. For soil profiles which did not have a B horizon, a modified ratio of

$$\frac{\text{maximum clay content in the 25-125 cm zone}}{\text{minimum clay content in the 0-25 cm zone}}$$

was determined and will be called sub/sur ratio. The results of this calculation are also presented in Table 13.

Shrader (1950) reported in his study of clay content of surface soils developed under prairie and forest vegetation that soils developed under the influence of prairie grass had a higher amount of clay in the surface horizon than the soils formed under forest vegetation. Transitional soils had an intermediate amount. He also noted that a soil in early stages of development will show an increase in clay content in the surface horizon and in the subsoil. Later in development, the soil will have a decrease in surface horizon clay with further subsoil clay increase. Collins' (1977) data agreed with

Table 13. Comparison of B/A or sub/sur clay ratios for soil association groups

Soil	B/A	sub/sur	
<u>Mo group</u>			
60		1.1	
Average			1.1
<u>GPS group</u>			
75	1.0		
71	1.0		
18	1.0		
21	.9		
81	1.2		
Average			1.0
<u>MIH group</u>			
97		1.0	
43	1.0		
Average			1.0
<u>M group</u>			
5	1.1		
36	1.0		
24	1.0		
Average			1.0
<u>SSM group</u>			
1	1.4		
88	1.3		
73	1.2		
Average			1.3
<u>ASE group</u>			
4	1.3		
Average			1.3
<u>CKL group</u>			
63	1.3		
Average			1.3

Table 13. (Continued)

Soil	B/A	sub/sur	
OMT group			
62	1.5		
44	1.1		
29	1.1		
79	1.2		
48	1.3		
54	1.6		
Average			1.3
GH group			
56	1.2		
Average			1.2
TM group			
86	1.1		
16	.9		
52	1.7		
Average			1.2
DT group			
38	1.1		
6	1.3		
Average			1.2
FDS group			
31-1	1.1		
Average			1.1
D group			
22-1	1.2		
22-2		1.2	
Average			1.2
F group			
96-1		1.2	
96-2		1.0	
31-2		1.1	
Average			1.1

Table 13. (Continued)

Soil	B/A	sub/sur	
<u>CNW group</u>			
95		.9	
Average			.9
<u>NE group</u>			
N1	.9		
N2		1.0	
N3	1.0		
N4	1.2		
Average			1.0
<u>MISSO group</u>			
M1	1.0		
M2	1.3		
M3	1.6		
M4	1.2		
Average			1.3
<u>ILL group</u>			
I	1.2		
I2	1.0		
Average			1.1
<u>MINN group</u>			
MINN1		1.0	
MINN2		.9	
Average			1.0

Shrader's observations. She reported that a Tama profile had a high amount of clay in the surface horizon, while the surface horizon of the Fayette contained a low amount. The Downs surface horizon had an intermediate amount.

Some of the Colo soil profiles were sampled in counties where the principal upland soils have formed in Wisconsin loess parent material and under prairie, transitional, or forest vegetation. Discussion will be restricted to principal upland soils associated with the Tama-Downs-Fayette biosequence. TM and DT groups represent prairie areas of east-central Iowa, D group represents transitional areas in northeastern Iowa, and F and FDS groups represent forested areas in northeastern Iowa.

As presented in Table 12 (principal upland soils), the TM and DT groups had the same amount of clay in the subsoil but there was 1% more clay in the surface of the TM group. The amount of clay in the surface of the D group was 21%. The subsoil had 30%. The F group had a clay content of 20% and 32% in the surface and subsoil, respectively. B/A clay ratios increased from prairie (1.2) to transitional (1.4) to forest (1.6). These amounts were the averages for the groups.

Means and weighted averages of Colo profiles in the soil association groups in Table 11 have similar clay contents in the surface and subsoil as the principal upland soils of the TM and DT groups. The amount of clay in the subsoil of the principal upland soils in D, FDS, and F groups is similar to the means and weighted averages in the Colo profiles in the D, FDS, and F groups. Therefore, there may be a correlation among clay contents in soils developed in alluvial sediments in prairie, transitional, and forested areas of the state compared to the clay contents in the surface layer and subsoil of the principal upland soils in those areas.

The drainage area of the streams associated with the respective Colo profiles in these groups was less than 153 km^2 except for Wolf Creek in Tama County. Wolf Creek has a drainage area of approximately 413 km^2 (Larimer, 1974). Most of the drainage area lies within the Tama-Muscatine soil association area.

Figures 21, 22, and 23 show the depth distribution of clay in TM, DT, F, D, and FDS groups, respectively. Clay content is relatively uniform with depth as compared to the principal upland soils. Little evidence is shown of eluviation or illuviation in the profiles.

Soils derived from glacial till are usually higher in sand to soils which are in loess regions of the state. The soil profile in Winnebago County (CNW group) was sampled on the floodplain of the Winnebago River. The Winnebago River north of Forest City, Iowa is a boundary between the typical Clarion-Nicollet-Webster soils area and soils of lacustrine origin such as Collinwood and Waldorf (Ronald Kuehl, USDA Soil Conservation Service, Ames, Iowa, personal communication).

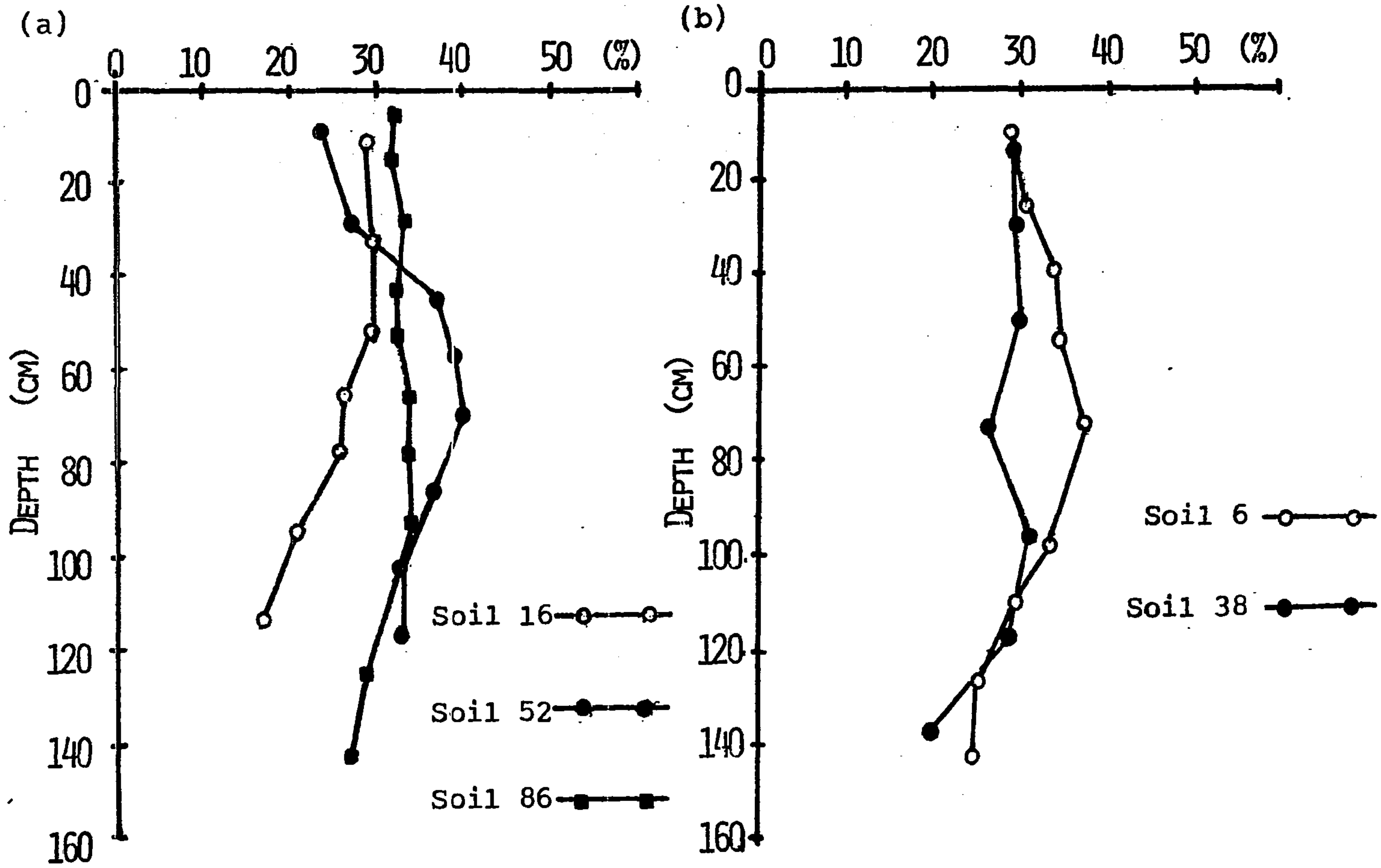


Figure 21. Clay depth distribution in Colo soils in (a) TM group and (b) DT group

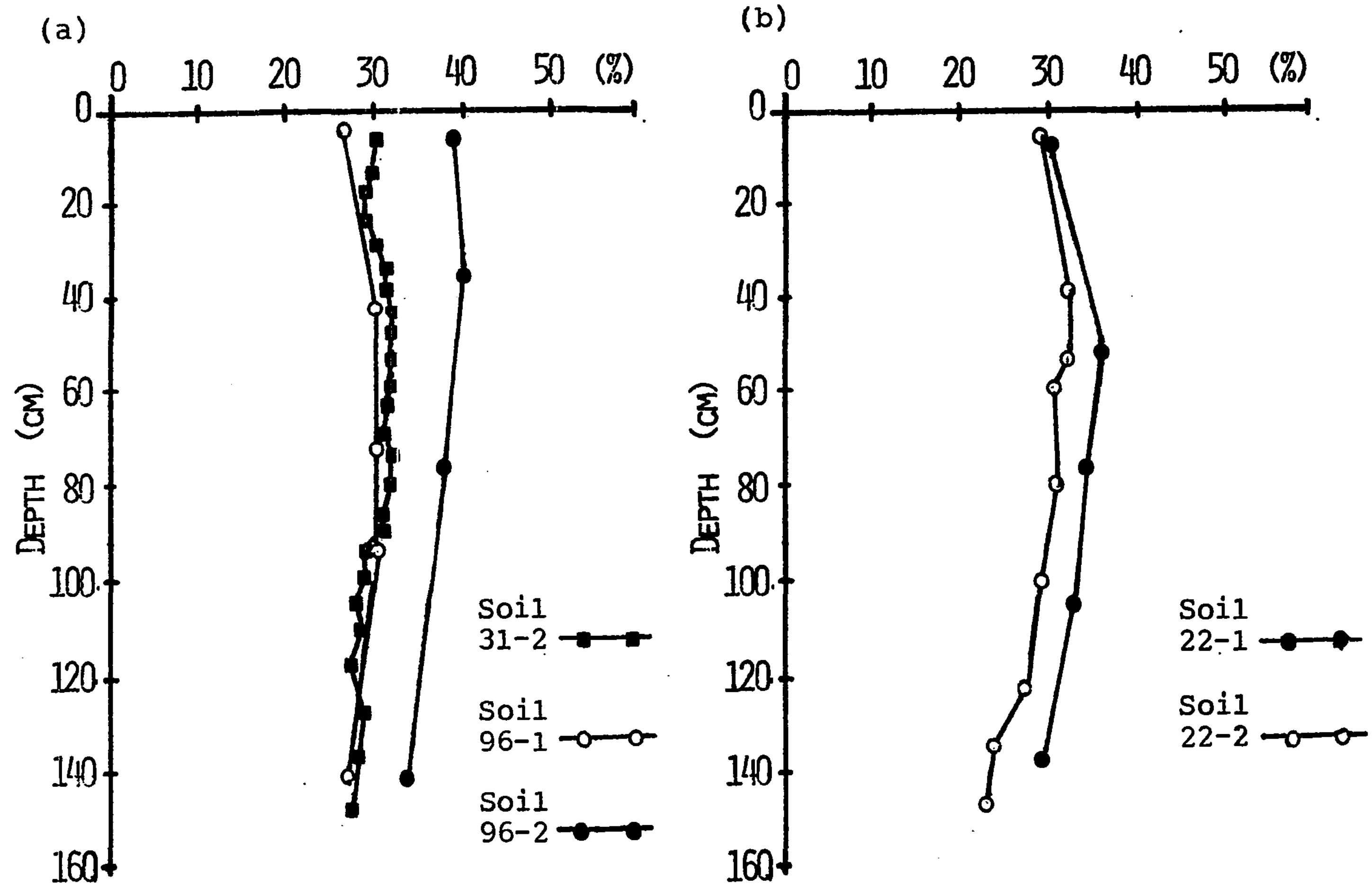


Figure 22. Clay depth distribution in Colo soils in (a) F group and (b) D group

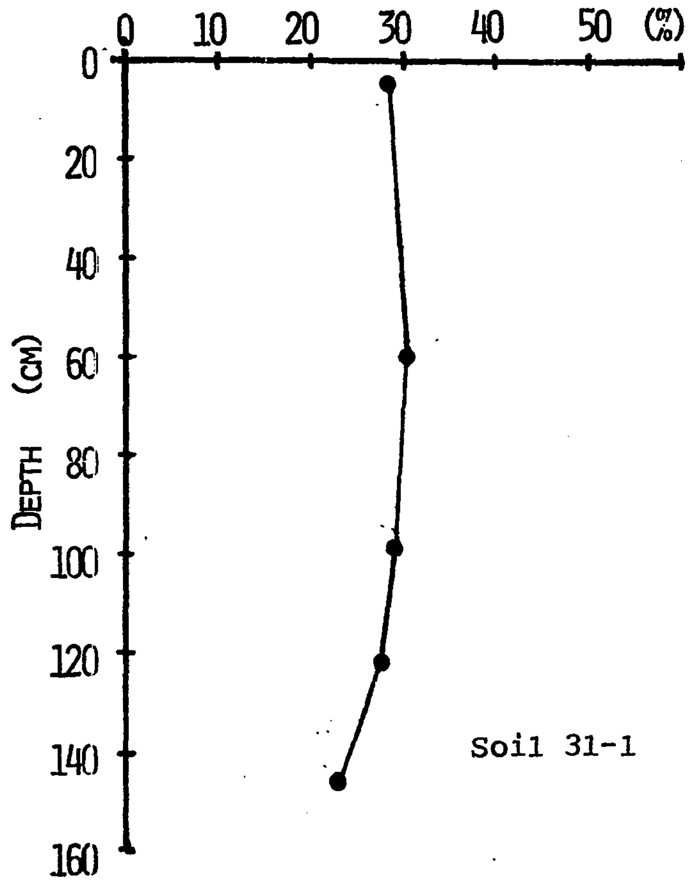


Figure 23. Clay depth distribution in Colo soils in FDS group

The Winnebago River is a major stream in northcentral Iowa. Its source is in southern Minnesota and the drainage area in Iowa is approximately 484 km^2 (Larimer, 1974). Therefore, the sources for the sediments are a mixture of Cary glacial drift (high in sand) and lacustrine material (high in silts and clay) of unknown origin. The mean clay, silt, and sand content of the Colo soils in the CNW group was 33.2%, 45.2%, and 21.6%, respectively. Clay content ranged from 24.8% to 39.4% with a weighted average of 31.5%. Total silt content ranged from 33.8% to 51.2% with a weighted average of 42.8%. Sand content increased with increasing depth in the Colo profile ranging from 10.0% to 41.4%. The weighted average for sand was 25.7%, which was the highest average for the Colo soils in all the groupings. Weighted averages for sand for the other groupings were generally below 15%.

The B/A clay ratio was 1.1 for the principal upland soils and .9 for the Colo soil in the CNW group.

The Mo and GPS Colo groups in northwest Iowa had clay content means and weighted averages of 30.1%, 30.0% and 34.0%, 34.1%, respectively. The Mo Colo group values are similar to the surface and subsoil clay contents in the principal upland soils. The GPS Colo group values are similar to the surface clay content in the principal upland soils.

The Colo profile in the Mo group in extreme northwestern Lyon County had a small increase in clay in the subsoil which is typical of many Mollisols (Figure 24). The clay contents

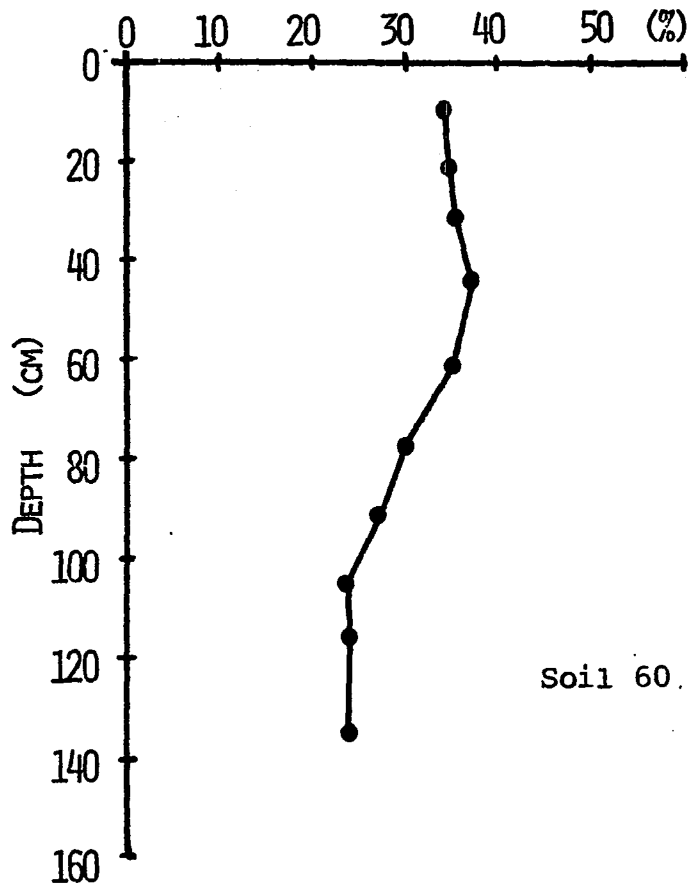


Figure 24. Clay depth distribution in Colo soil in Mo group

in the GPS group did not increase with depth.

NE, MISSO, ILL, and MINN Colo groups clay contents are shown in Figures 25 and 26. All horizons in MINN2 have clay contents outside the range for the Colo series.

Most of the clay depth distributions in NE and MINN groups had a pattern that approximated a straight line. Some of the clay depth distribution curves do have a significant increase with depth as in M2, M3, M4, and I profiles.

Averaging the B/A and sub/sur clay ratios, .9 and 1.3, respectively, indicated little to moderate amounts of clay movement in the Colo soils.

<u>Simple correlation coefficients between particle-size and other soil variables</u>

Simple correlation coefficients between particle-size and other laboratory variables were computed and the results are presented in Appendix E for those interrelated variables whose correlation coefficients were greater than $\pm.20$. Sand, silt, and clay contents were highly correlated ($r \pm >.80$) with several laboratory variables in each group. No regional trends were found. Trends within groups may be the result of other decreasing values with depth (TC) versus increasing values with depth (CLAY), increasing values with depth of both variables (SAND and TK), or some combination of these variables.

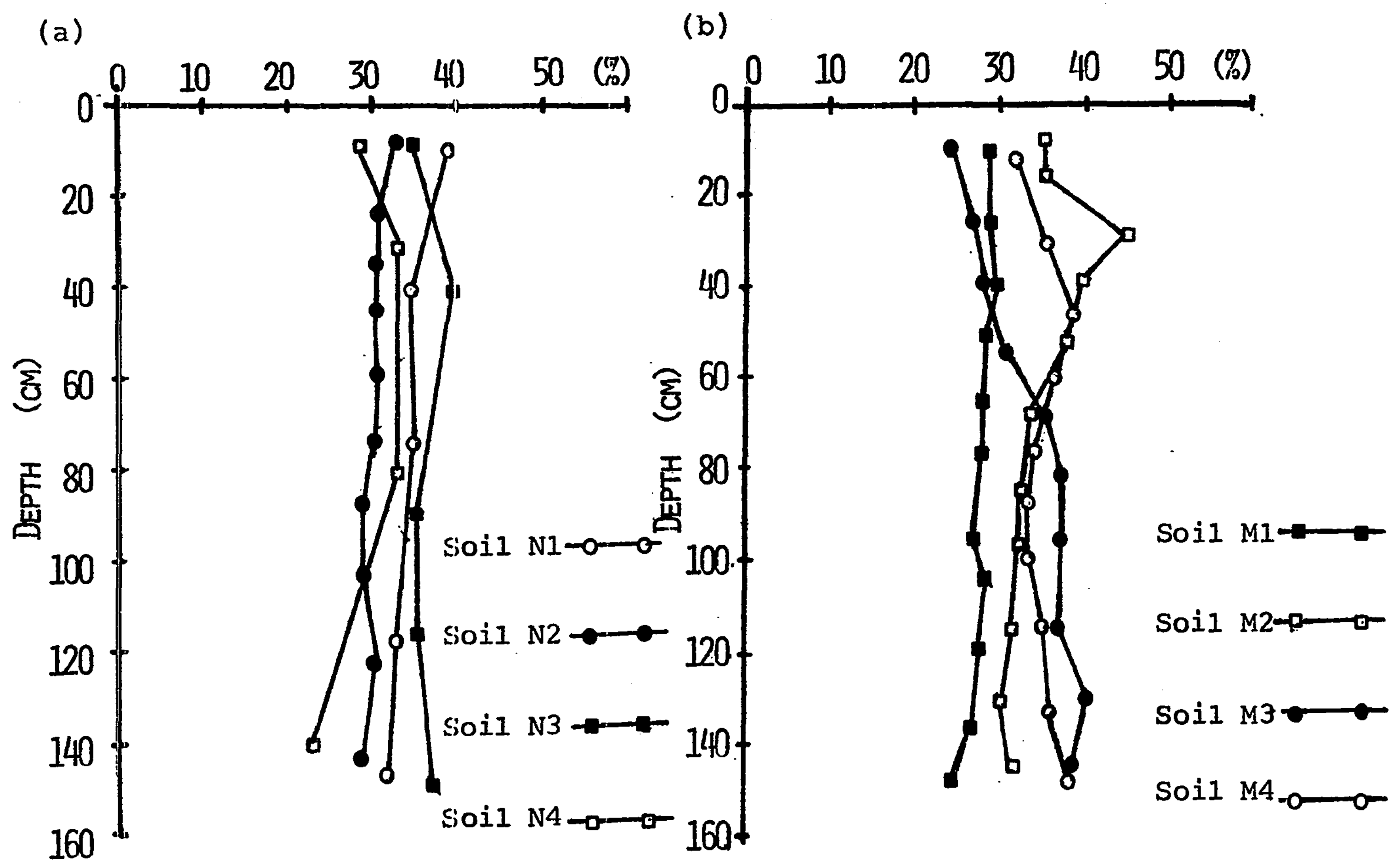


Figure 25. Clay depth distribution in Colo soils in (a) NE group and (b) MISSO group

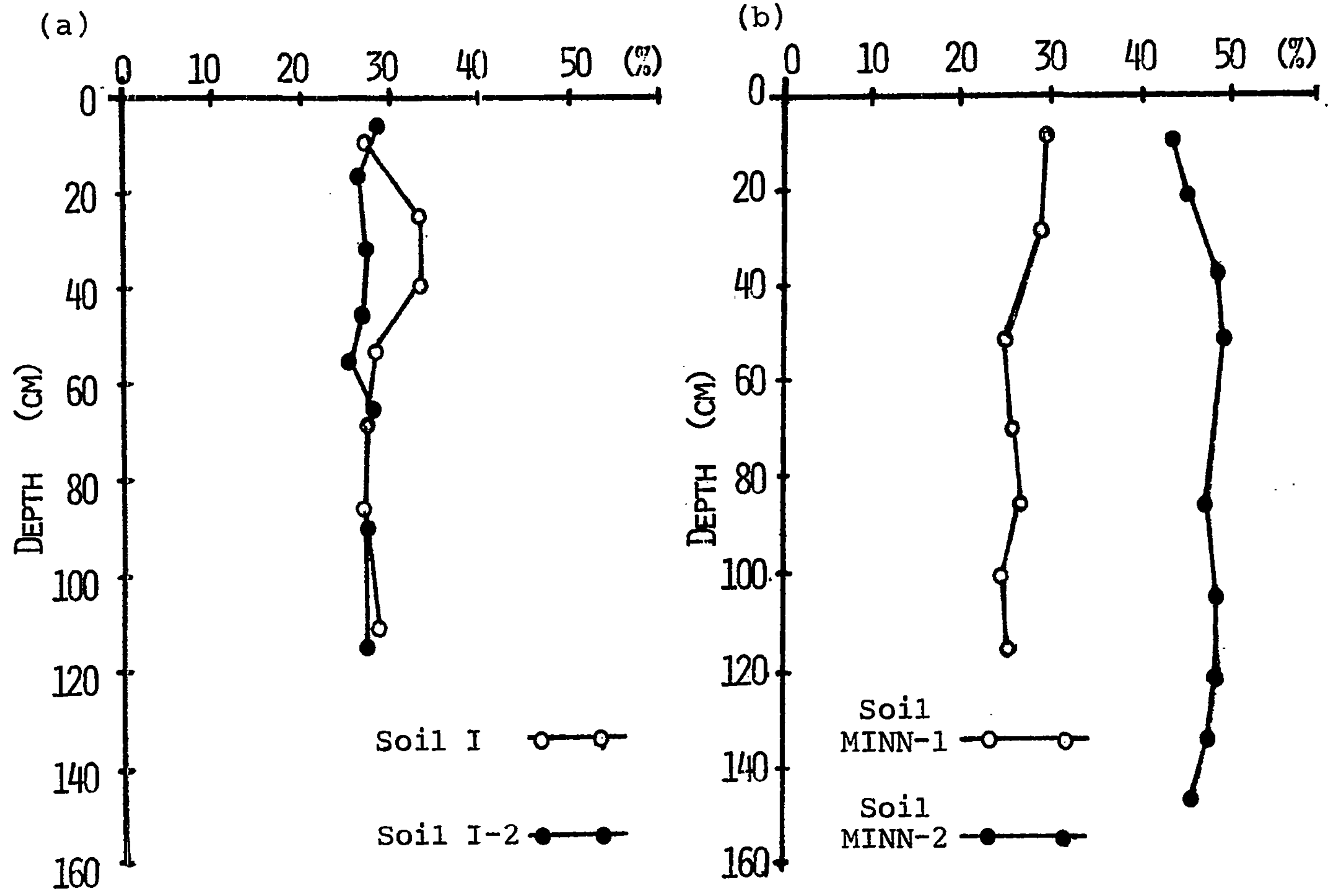


Figure 26. Clay depth distribution in Colo soils in (a) ILL group and (b) MINN group

Available phosphorus (AVP) distribution

Means, minimum values, maximum values, and weighted averages of AVP of Colo profiles were calculated and are listed in Table 11. The means and weighted averages ranged from 49 ppm and 48 ppm, respectively, in the MIH group to 6 ppm and 5 ppm, respectively, in the ILL group.

The Colo profiles were collected in prairie, transitional or forested areas of the state, weighted averages of the control sections (25 to 100 cm) were calculated for the TM, DT, D, FDS, and F groups to determine if a correlation exists between the amount of AVP in the control section and the biotic factor. The AVP depth distribution for the TM, DT, D, F, and FDS groups are shown in Figures 27, 28, and 29. The weighted averages for these groups are 22, 14, 13, 19, and 19 ppm, respectively. Collins (1977) reported 19 ppm AVP weighted average for a Tama profile. Also, she reported a weighted average of 25 ppm AVP for a Downs profile and 16 ppm AVP for a Fayette profile. The AVP content in the Fayette profile increased below 100 cm. All were sampled in Tama County. These weighted averages were higher than the weighted averages reported by Tembhare (1973) for Alfisols and Mollisols, but are within his range. Kuehl (1978) reported a weighted average of 25.6 ppm for soil M-163B (Fayette) sampled in Clayton County.

In some profiles, the pH was above 7.0 and the high pH values probably affected the amount of AVP measured. Figures 30a and 30b show the hogh pH and low AVP content of several

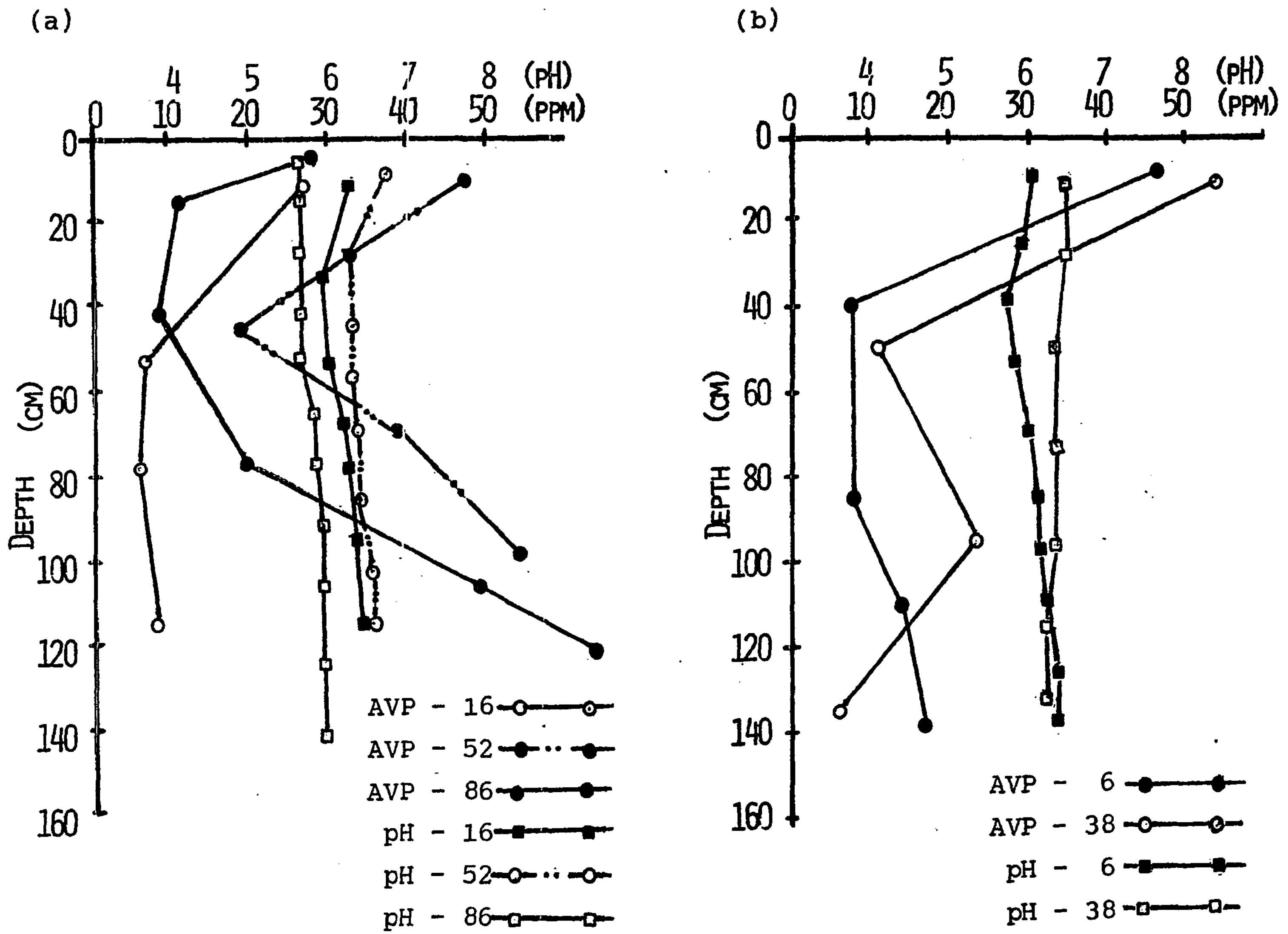


Figure 27. AVP and pH depth distribution in Colo soils in (a) TM group and (b) DT group

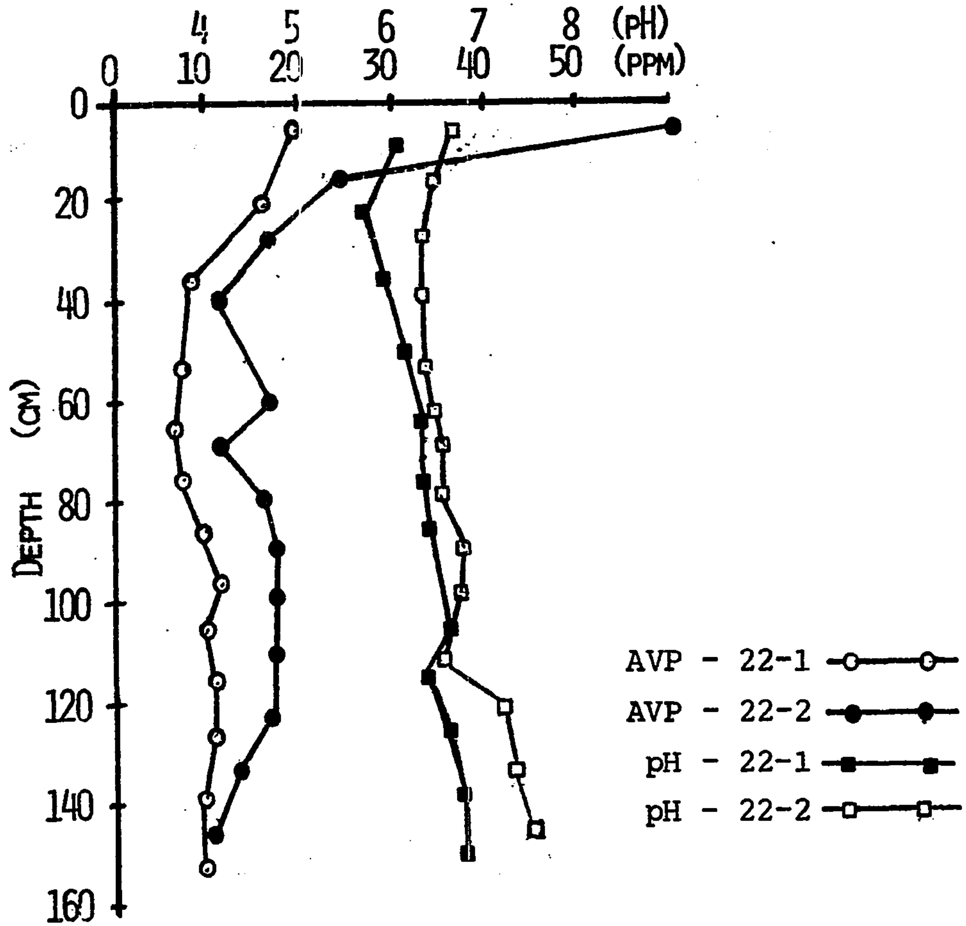


Figure 28. AVP and pH depth distribution in Colo soils in D group

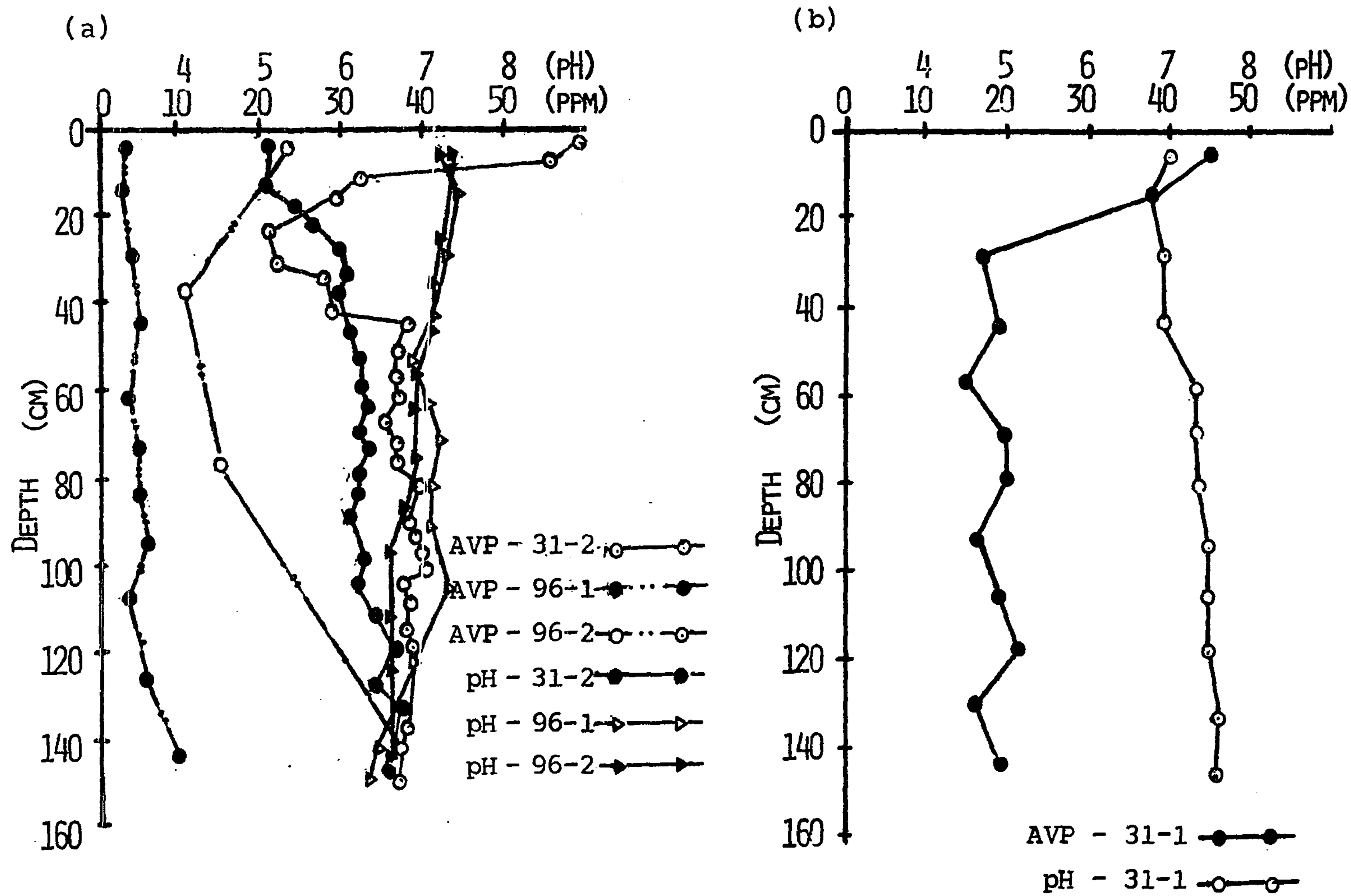


Figure 29. AVP and pH depth distribution in Colo soils in (a) F group and (b) FDS group

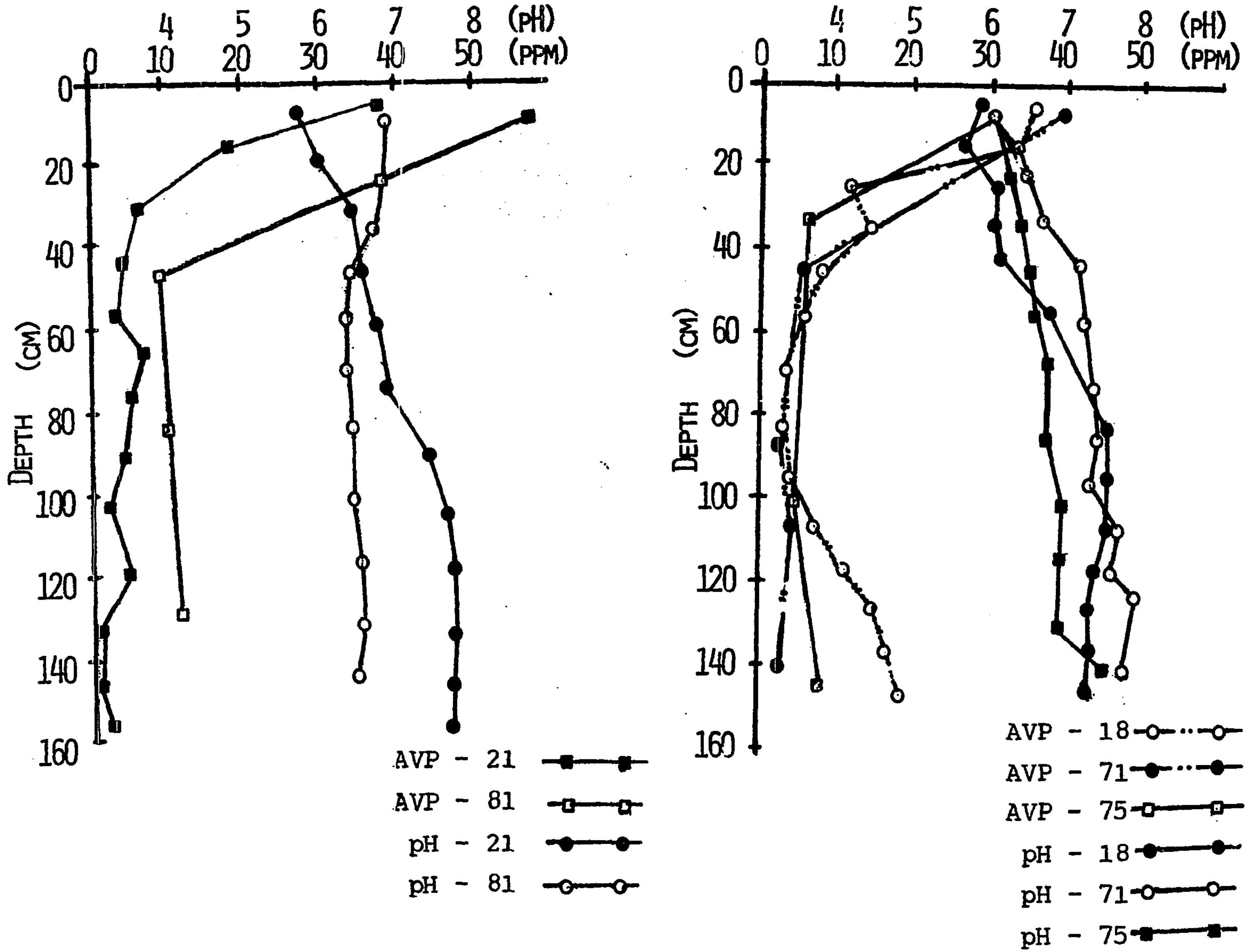


Figure 30. AVP and pH depth distribution in Colo soils in GPS group

Colo profiles in northwestern Iowa. Smeck and Runge (1971) stated that the availability of soil phosphorus is pH dependent. At low pH levels, the phosphate is held by hydrous oxides of iron, aluminum and manganese. At high pH's, the phosphate is fixed as calcium phosphate. Miller (1974), Collins (1977), and Kuehl (1978) also noted a decrease in AVP content of soils that had high pH values.

Another reason for the apparent lack of a trend is that some of the Colo profiles in each group reached a minimum in AVP at about 40 cm (Figure 31). Most of the AVP values decreased in the upper portion of the control section and then slightly increased in the lower portion of the control section resulting in low weighted averages.

The AVP depth distribution shows that most Colo profiles did have a minimum (eluviated) zone and a maximum (illuviated) zone as do most upland soils but in some profiles this was not as well-expressed. An example of a Colo profile which did have well-expressed eluviated and illuviated zones was N2 in the NE group (Figure 32a). The AVP content in the Ap horizon was 37 ppm and decreased in the A12 horizon to 20 ppm. The maximum AVP content was in the A15 horizon (60 ppm). A reason for this trend may be related to the depth to the water table. Soil scientists in Nebraska consider Colo to be a somewhat poorly drained soil. Well-drained and somewhat poorly drained soils typically have zones of eluviation and illuviation. Tembhare (1973) reported that the well-drained Hayden soil

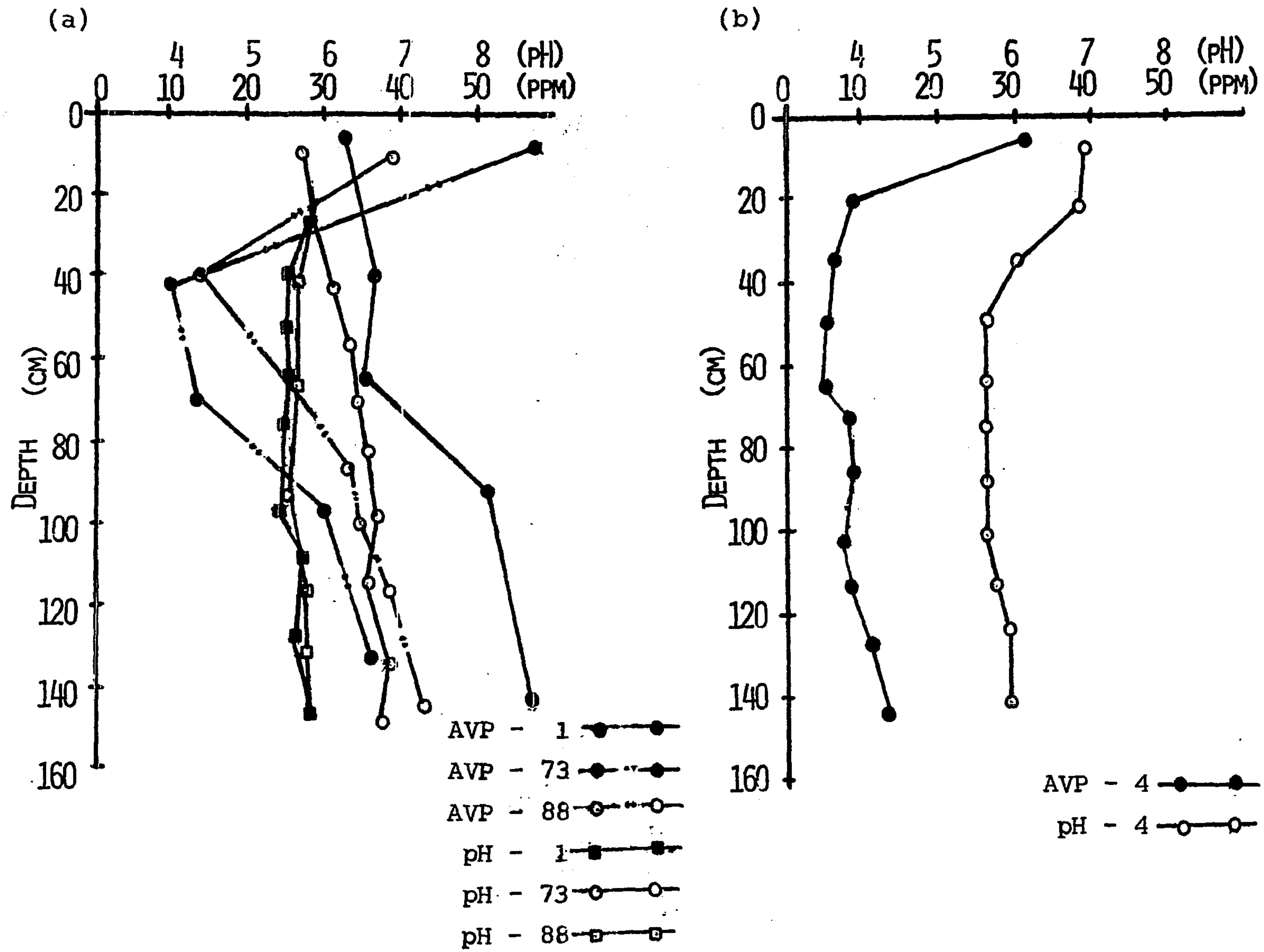


Figure 31. AVP and pH depth distribution in Colo soils in (a) SSM group and (b) ASE group

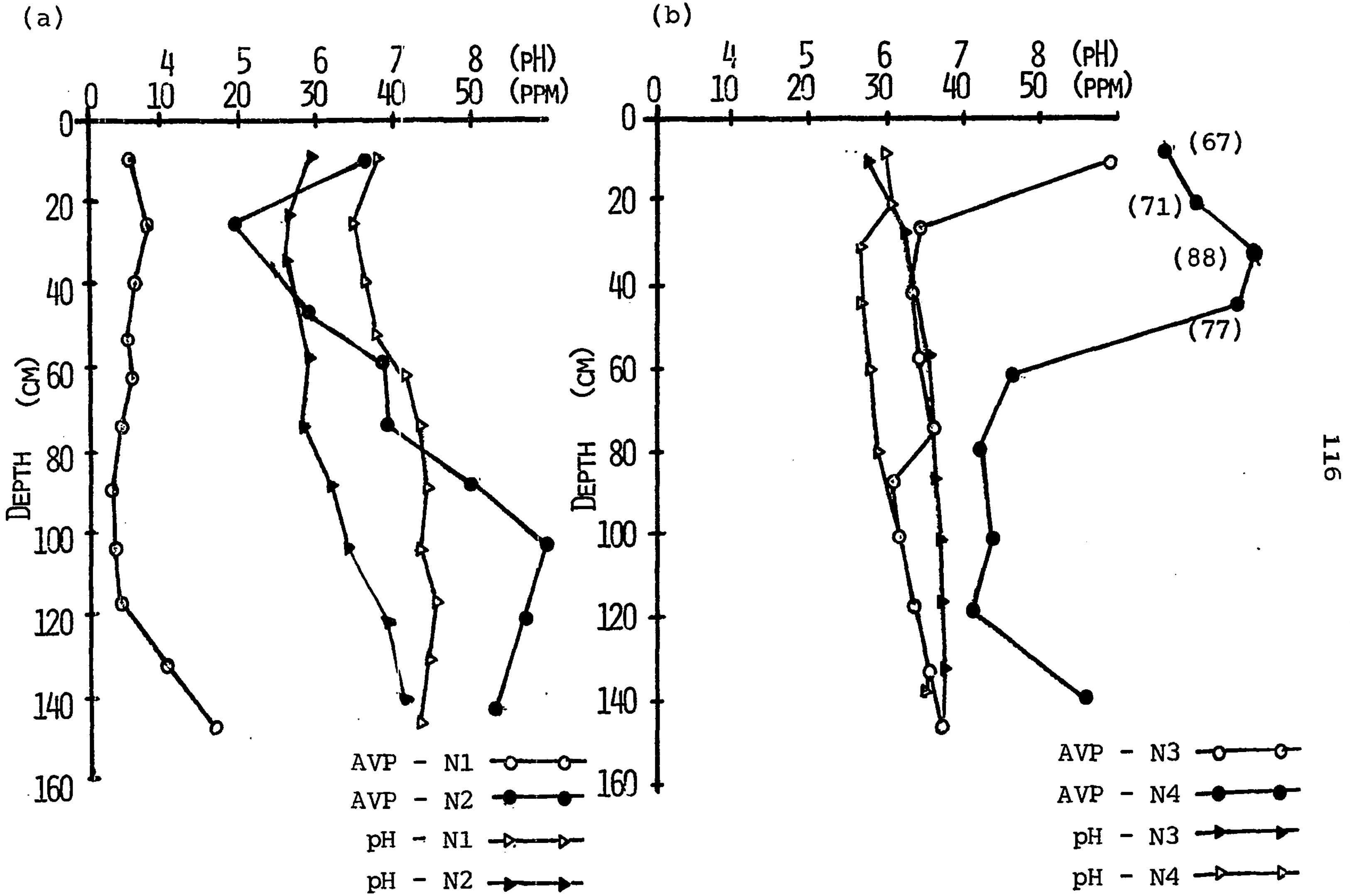


Figure 32. AVP and pH depth distribution in Colo soils in NE group

was higher in AVP content than the somewhat poorly drained Luther and poorly drained Ames soils. Collins (1977) also noted similar trends in her Tama-Muscatine-Garwin and Wiota-Nevin-Bremer toposequences. The reason for the differences may be that the carbonates were leached to a greater depth which resulted in lower pH values. This may explain the contrast between N2 profile and the AVP content in the other Colo profiles sampled in Nebraska (Figure 32).

The other Colo profiles had a decreasing AVP content with increasing depth. This trend is illustrated in Figures 28 and 30, for D and GPS groups.

The degree of profile development and the soil's genesis as influenced by vegetative cover influences the distribution of AVP with a profile. Runge and Riecken (1966), Tembhare (1973), Miller (1974), Smeck and Runge (1971), Collins (1977), Kuehl (1978) and others have studied AVP relationships. Some of their conclusions were: (1) In general, AVP is higher in the surface layer and decreases to a minimum in the lower A or upper B horizons. The AVP minimum in the lower A or upper B horizon is the result of the removal of soluble phosphorus from this area by plant roots or eluviation. The AVP maximum in the B horizons and upper C horisons is due to the lack of plant removal, illuviation, and pH. (2) AVP redistribution may be an indication of profile development. A weighted average AVP for the control section may be compared to the B/A clay ratio. (3) Alfisols have a higher weighted average AVP for the control section than Mollisols. Therefore, it may be possible to understand the genesis of the soil by the AVP weighted average for the control section. (4) At pH values above 7.0, AVP determinations (Bray 1) depend on the solubility of the phosphates. (5) The clay maximum occurs higher in the B horizon than the AVP maximum in most soils. These conclusions were based on results obtained from studying biosequences of upland soils. AVP distributions in soils derived in alluvial sediments have not been studied as intensively as upland soils nor have AVP results of soils formed in alluvial sediment been used to aid in determining the genesis (vegetation factor) in these soils.

STAVP, soil pH (STHION), and soil buffer pH (STBHION) were determined in selected Colo profiles by the Iowa Soil Testing Laboratory. The results of those analyses are presented in Appendix B.

The Iowa Soil Testing Laboratory summarizes the soil testing results of the soil samples for available phosphorus, available potassium, pH, buffer pH, and other analyses and presents the results in a bulletin (Eik, 1980). The summary of soil test results in the bulletin are listed by soil area, county, and soil type. The soil tests were performed on 75,000 samples from January 1974 to the end of June 1979.

The percentage of a soil association area in a watershed was determined using the 1978 Iowa Soil Association map. For example, the Colo profile sampled in Benton County was in the Spring Creek Watershed. The area of the watershed was delineated on the soil association map and the number of sections was noted for each soil association area and a percentage calculated. Three soil association areas were within the Spring Creek Watershed. The principal upland soil in each soil association area was determined from the soil type and distribution (%) information compiled by Fenton (T. E. Fenton, Department of Agronomy, Iowa State University, unpublished data). AVP content of the principal upland soils in each soil association area was obtained from the information given in the Summary of Soil Test Results 1974-1979 (Eik, 1980) using the mean of each soil type. The majority of the samples tested at the soil testing laboratory are collected from the plow layer or surface layer. To obtain AVP contents in the subsoils (76-107 cm) of principal upland soils in each soil association area, data gathered by Iowa State University for a statistical study were used. The results of the final calculations for AVP in the surface (0~20 cm) and 76-107 cm are presented in Table 14 by soil groups.

Results obtained in this study (Table 14) indicate that the average AVP content of the surface layer of the Colo soils groups are generally higher than the average AVP content in the surface layer of the principal upland soils in each group.

Table 14. Comparison of AVP content for different depths as determined by Soil Testing Laboratory, Collins, and for statistical study

	AVP content					
	STD[a]	SS[b]	Collins[c]		STL[d]	
Soil	0–≈20 cm	76–107 cm	0–20 cm	76–107 cm	0–20 cm	76–107 cm
	ppm					
Mo group						
60	26	13	156	18	85	5
Average	26	13	156	18	85	5
GPS group						
75	27	4	31	6	15	5
71	27	4	40	4	–	–
18	27	5	35	4	–	–
21	27	5	37	4	17	3
81	27	6	57	11	49	12
Average	27	5	40	6	27	7
MIH group						
97	27	5	80	30	55	23
43	25	9	73	63	64	49
Average	26	7	77	47	60	36
M group						
5	23	11	73	38	–	–
36	23	12	50	32	89	19
24	23	11	30	18	–	–
Average	23	11	51	29	89	19

[a]Soil test data of principal upland soil in each group (1974-1979).

[b]Statistical study, AVP content in the principal upland soil in each group.

[c]AVP content in Colo profiles determined by Collins.

[d]STAVP content in Colo profiles determined by Iowa Soil Testing Laboratory, Ames, Iowa.

Table 14. (Continued)

Soil	AVP content: STD 0–≈20 cm	SS 76–107 cm	Collins 0–20 cm	Collins 76–107 cm	STL 0–20 cm	STL 76–107 cm
	ppm					
SSM group						
1	19	18	32	49	32	19
88	19	18	39	33	30	21
73	21	17	70	26	53	11
Average	20	18	47	36	38	17
ASE group						
4	12	8	32	7	-	-
Average	12	8	32	7	-	-
CKL group						
63	21	13	29	15	27	8
Average	21	13	29	15	27	8
OMT group						
62	28	17	54	9	-	-
44	29	18	53	48	52	31
29	29	18	103	36	103	18
79	25	11	8	2	-	-
48	25	11	33	12	28	9
54	25	11	44	8	-	-
Average	27	14	49	19	61	19
GH group						
56	21	14	23	4	24	6
Average	21	14	23	4	24	6
TM group						
86	26	18	27	34	25	21
16	26	18	27	7	-	-
52	26	18	47	50	38	38
Average	26	18	34	30	32	30
DT group						
38	26	18	55	22	-	-
6	26	15	46	10	52	9
Average	26	17	50	16	52	9

Table 14. (Continued)

Soil	AVP content					
	STD	SS	Collins		STL	
	0–≈20 cm	76–107 cm	0–20 cm	76–107 cm	0–20 cm	76–107 cm
	ppm					
FDS group						
31-1	22	23	42	18	59	-
Average	22	23	42	18	59	-
D group						
22-1	22	23	20	11	31	11
22-2	22	23	60	18	-	-
Average	22	23	40	15	31	11
F group						
96-1	24	5	4	5	-	-
96-2	22	11	23	20	-	-
31-2	22	23	48	39	52	36
Average	23	13	25	21	52	36
CNW group						
95	27	51	4	56	22	15
Average	27	51	4	56	22	15

The reason for this may be that the Colo soils receive sediments from the upland soils. Phosphorus is transported in the sediment and, therefore, the surface layer of the Colo soils accumulates phosphorus resulting in higher values of AVP. The amount of phosphorus in solution from the flooding stream is not known. Another reason for the high AVP values in the surface layer is the soil pH. The pH may be low in the surface layer but increases with depth. The result would be higher AVP values in the surface layer as compared to the subsoil.

Average subsoil levels of AVP in the Colo soils and the principal upland soils are very similar in some groups, for example, GPS, ASE, and OMT. Most of the groups had a lower amount of AVP in the subsurface as compared to the surface layer. Possible explanations for this are (1) the application of phosphate fertilizer to the surface layer, giving higher AVP values. Weighted averages calculated for chemical properties, except TC and TK, excluded the surface layer sample because of this reason. (2) In many soils, the maximum AVP content is not reached in the subsoil at 76-107 cm but at greater depths. (3) Phosphorus accumulates in the surface layer and has not leached to greater depths in the profiles.

Simple correlation coefficients between AVP and STAVP and other soil variables

Simple correlation coefficients were computed between AVP and other variables for the Colo soil groups and are listed in Appendix E for those interrelated variables whose r value was greater than $\pm .20$. This procedure was done to determine if there were significant correlations between AVP and STAVP and other variables.

High r values ($\geq \pm .80$) were computed for CKL (.87), ASE (.86), OMT (.82), and GH (.96) groups of southern Iowa for the relationship of AVP and TP. AVP and STAVP were highly correlated for DT, D, and Mo groups (.99, .81, .93, respectively). This is a comparison of laboratory procedures. Correlation coefficient of .98 was calculated for AVP and HION in Mo group. Also in the Mo group, high r values were attained between AVP and STAVK (.98), STHION (.99), and STBHION (.97).

STAVP was highly correlated with STAVK for M (.99), GH (.98), DT (.98), ILL (.98), Mo (.91), D (.88), and MISSO (.88) groups. Negative correlations existed with STAVP and STHION and STBHION in the NE group (-.83 and -.86, respectively). STAVP and STHION were positively related to STHION and STBHION in the Mo group (.91 and .93, respectively). Also, STAVP was highly correlated with STBHION for the GH group (.88).

Total phosphorus, inorganic phosphorus, and organic phosphorus

Total phosphorus (TP), inorganic phosphorus (IP), and organic phosphorus (OP) contents were determined on the majority of the Colo soil samples collected for this regional research project. The TP content ranged from a minimum of 188 ppm to a maximum of 1045 ppm. The mean and weighted averages were 527 ppm, and 517 ppm, respectively (Table 5). IP content in the Colo soils ranged from 63 ppm to 850 ppm. OP minimum and maximum values were 7 ppm and 795 ppm, respectively. The means and weighted averages for IP and OP are given in Table 5.

The amount of TP and the depth distribution of TP within the profile have been used as indicators of the mode of soil genesis. Runge and Riecken (1966) in their study on the influence of natural drainage on the distribution of phosphorus in Iowa prairie soils, noted an eluviated zone of phosphorus extending from 0 to .9 meters and an illuviated zone of phosphorus from .9 to 1.8 or 2.4 meters. Collins (1977) reported each profile of the Tama-Downs-Fayette biosequence had a zone of TP eluviation and illuviation. Depths to these zones varied among the profiles. Fenton et al. (1967) reported that the depth to the TP minimum within a biosequence was least in the forested member, intermediate in the transitional member, and greatest in the prairie member.

Phosphorus may be removed in the eluviated zone by (1) a recycling process by plants in which the plant roots absorb inorganic phosphorus, transport the phosphorus in the plant, and return organic phosphorus to the soil upon the death of the plant; and (2) downward movement of phosphorus by water percolating through the profile (Runge and Riecken, 1966; Godfrey, 1951; Ryan, 1959). The accumulation of phosphorus may be due to plants not removing inorganic forms of phosphorus at great depths in the soil or the illuviation of TP.

The "typical" TP curves for upland soils have a sigmoid (S-shaped) curve. The curve decreases with depth to a minimum amount in the area of the lower A and upper B horizons. In the middle and lower B horizons the amount increases (Pearson et al., 1940; Runge and Riecken, 1966; Godfrey and Riecken, 1954; Smith et al., 1950). Generally, the maximum amount of TP is in the lower B or upper C horizons. Table 15 presents the I/E (illuviated/eluviated) ratios calculated for the Colo profiles by groups. Also listed are the depth to minimum TP and the amount at that depth, maximum TP and the amount at that depth, and a weighted average for 0-130 cm zone.

The degree of profile development may be indicated by studying TP depth distribution. There is a greater differentiation between quantity of phosphorus gained by illuvial horizons and loss by eluvial horizons with increasing profile development. This observation is based on the fact that phosphorus is essentially immobile in soils but can be redistributed over long periods of time (Smeck, 1973; Smeck and Runge, 1971).

A calculation similar to the B/A clay ratio was devised by Collins (1977) to indicate the relative degree of profile development of similar soils. This ratio was called an I/E ratio and is calculated by dividing the maximum TP content by the minimum TP content in the soil profile below the A horizon. A soil with a low value may be interpreted as having little phosphorus movement in the profile. Profiles with large I/E values should have well-expressed eluviation and illuviation zones in the depth distribution of TP. Examples are soil 95 (Figure 33) with an I/E ratio of 2.4 and soil 86 in the TM group with an I/E ratio of 2.1.

A zone of eluviation is well-expressed in soil 95 of the CNW group (Figure 33) for TP and IP. The IP curve parallels

Table 15. Summary of TP properties by soil association groups

Soil	Minimum TP (ppm) and depth (cm)	Maximum TP (ppm) and depth (cm)	I/E ratio	Weighted average 0-130 cm (ppm)
Mo group				
60	448, 62	615, 134	1.4	506
Average	448, 62	615, 134	1.4	506
GPS group				
75	336, 85	396, 145	1.2	519
71	300, 86	497, 141	1.7	402
18	262, 83	379, 147	1.4	356
21	319, 57	655, 165	2.1	419
81[a]	-, -	-, -	-	494
Average	304, 78	482, 150	1.6	438
MIH group				
97[a]	-, -	-, -	-	721
43	603, 70	787, 145	1.3	741
Average	603, 70	787, 145	1.3	731
M group				
5	500, 98	550, 145	1.1	637
36	443, 84	628, 146	1.4	561
24	336, 79	522, 129	1.6	530
Average	426, 87	567, 140	1.4	576
SSM group				
1	488, 79	541, 145	1.1	603
88	466,115	525, 130	1.1	460
73	450, 42	560, 147	1.2	525
Average	468, 79	542, 141	1.1	529
ASE group				
4	188, 64	353, 141	1.9	263
Average	188, 64	353, 141	1.9	263

[a]TP did not increase below minimum.

Table 15. (Continued)

Soil	Minimum TP (ppm) and depth (cm)	Maximum TP (ppm) and depth (cm)	I/E ratio	Weighted average 0-130 cm (ppm)
CKL group				
63	262, 75	373, 123	1.4	316
Average	262, 75	373, 123	1.4	316
OMT group				
62	232,128	319, 144	1.3	411
44	616,132	750, 146	1.2	715
29	373, 87	492, 138	1.3	539
79	205, 77	452, 172	2.2	294
48[a]	- -	- -	-	405
54	310,114	396, 144	1.3	477
Average	347,108	482, 149	1.5	474
GH group				
56	300, 69	448, 144	1.5	394
Average	300, 69	448, 144	1.5	394
TM group				
86	446, 92	923, 141	2.1	482
16	338, 66	528, 114	1.6	458
52	678, 45	900, 116	1.3	631
Average	487, 68	784, 124	1.7	524
DT group				
38	475, 73	578, 115	1.2	594
6	415, 70	743, 107	1.8	632
Average	445, 72	661, 111	1.5	613
FDS group				
31-1[a]	- -	- -	-	726
Average	- -	- -	-	726
D group				
22-1	389, 75	651, 149	1.7	530
22-2[a]	- -	- -	-	742
Average	389, 75	651, 149	1.7	636

Table 15. (Continued)

Soil	Minimum TP (ppm) and depth (cm)	Maximum TP (ppm) and depth (cm)	I/E ratio	Weighted average 0-130 cm (ppm)
F group				
96-1[a]	- -	- -	-	867
96-2[a]	- -	- -	-	742
31-2[a]	- -	- -	-	637[b]
Average	- -	- -	-	749
CNW group				
95[b]	375, 63	914, 145	2.4	564
Average	375, 63	914, 145	2.4	564
NE group				
N1	362,115	419, 145	1.2	414
N2[c]	568, 43	918, 102	1.6	686
N3	452,117	512, 146	1.1	512
N4	413,120	483, 140	1.2	538
Average	449, 99	583, 133	1.3	538
MISSO group				
M1	318,117	397, 146	1.2	411
M2	334,129	417, 144	1.2	557
M3[a]	- -	- -	-	455
M4	224, 73	366, 130	1.6	274
Average	292,106	393, 140	1.3	424
ILL group				
I[a]	- -	- -	-	642
I2[a]	- -	- -	-	405
Average	- -	- -	-	524
MINN group				
MINN1[c]	450, 37	886, 146	2.0	512
MINN2[c]	188, 50	675, 84	3.6	417
Average	319, 44	781, 115	2.8	465

[b]Entire profile was not analyzed.

[c]A B horizon was not described. Minimum amount was calculated in A horizon.

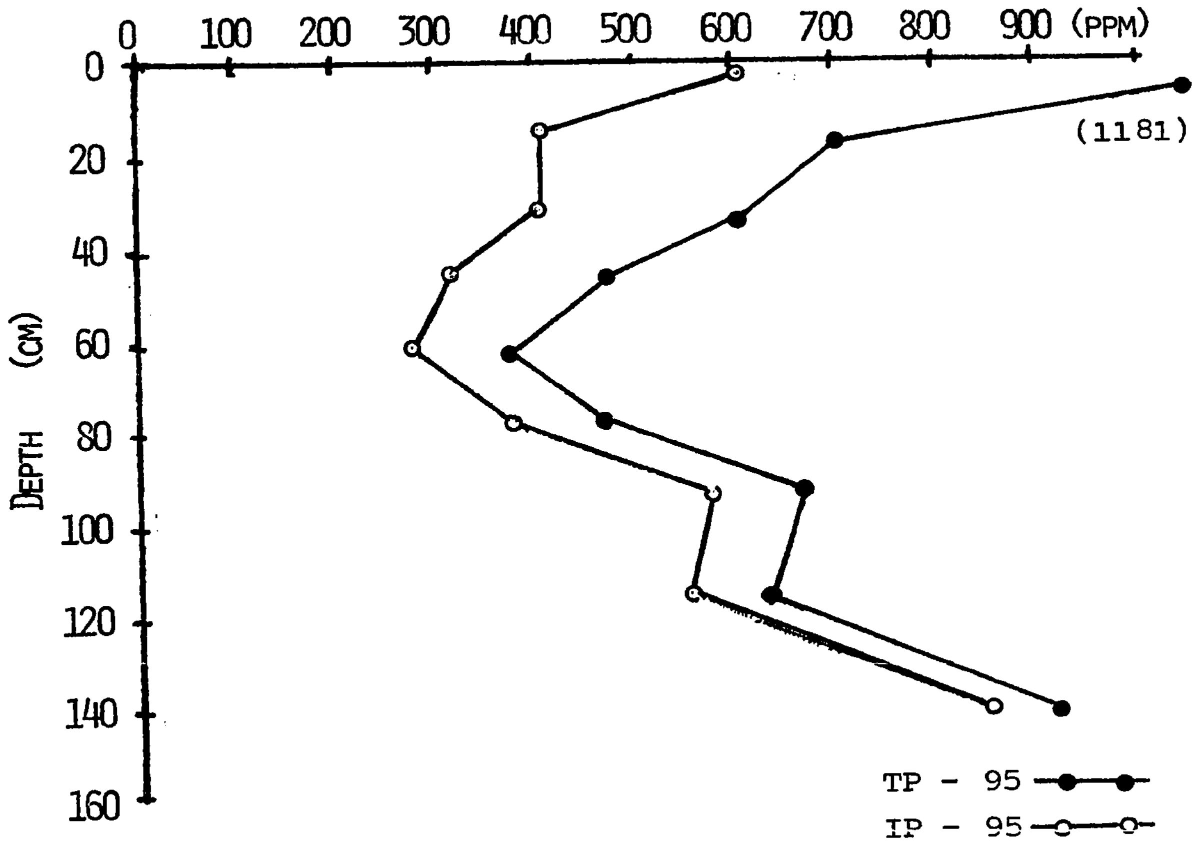


Figure 33. TP and IP depth distribution in soil 95 in the CNW group

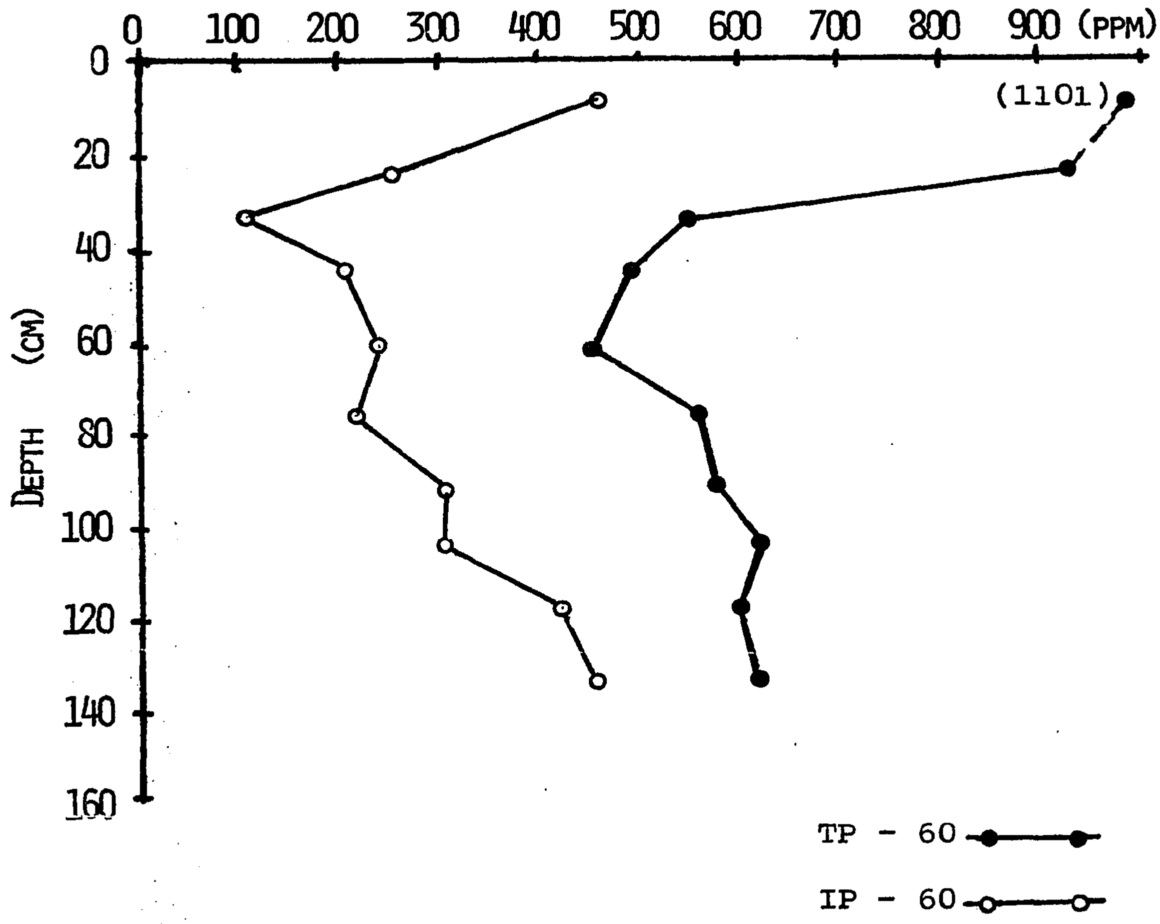


Figure 34. TP and IP depth distribution in soil 60 of the Mo group

the TP curve and both curves reach a minimum at 63 cm. Generally, the curves continued to increase to the maximum depth sampled.

TP content in soil 95 was highest (1181 ppm) in the A11 horizon. Approximately half of the phosphorus in the surface horizon comes from organic sources. The Colo soil is considered to have relatively high amounts of organic matter as it is dark colored and has a high TC content. Therefore, this soil should have relatively large amounts of organic phosphorus. OP content was high (581 ppm) in the A11 horizon as was the TC content (3.6%). OP and TC (Figure 35) amounts decreased with increasing depth in soil 95. OP/TP ratios were calculated by dividing the OP content by by the TP content multiplied by 100 giving the percentage of phosphorus attributed to organic sources. This ratio also decreased with increasing soil depth. This is an indication of lower amounts of OP and higher amounts of IP which would be expected with decreasing amounts of TC.

In contrast to the TP and IP depth distribution in soil 95 of the CNW group is the TP and IP depth distribution in soil 63 of the CKL group (Figure 36). A weakly expressed eluviated zone is shown by the TP curve. The IP curve is almost a straight line except for the 56 to 94 cm zone. The OP content ranges from 160 ppm in the surface horizon to 87 ppm in the B22 horizon (69-81 cm). TC content is also low (1.2%) in the Ap horizon compared to soil 95.

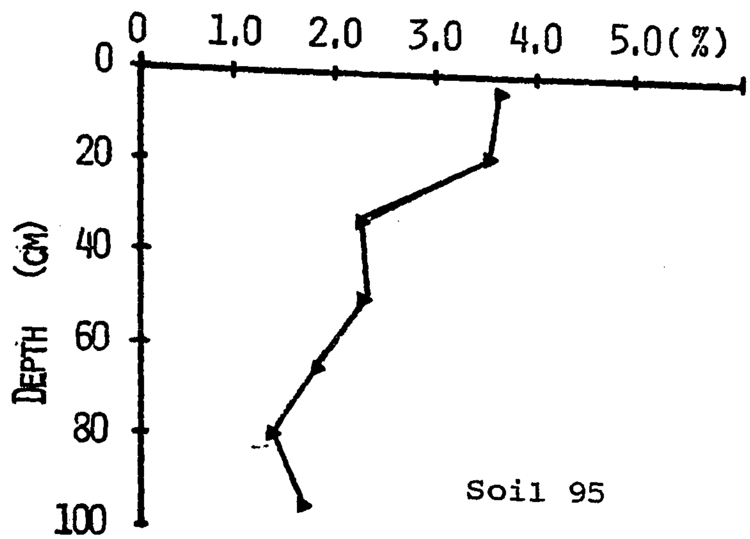


Figure 35. TC depth distribution in soil 95 of the CNW group

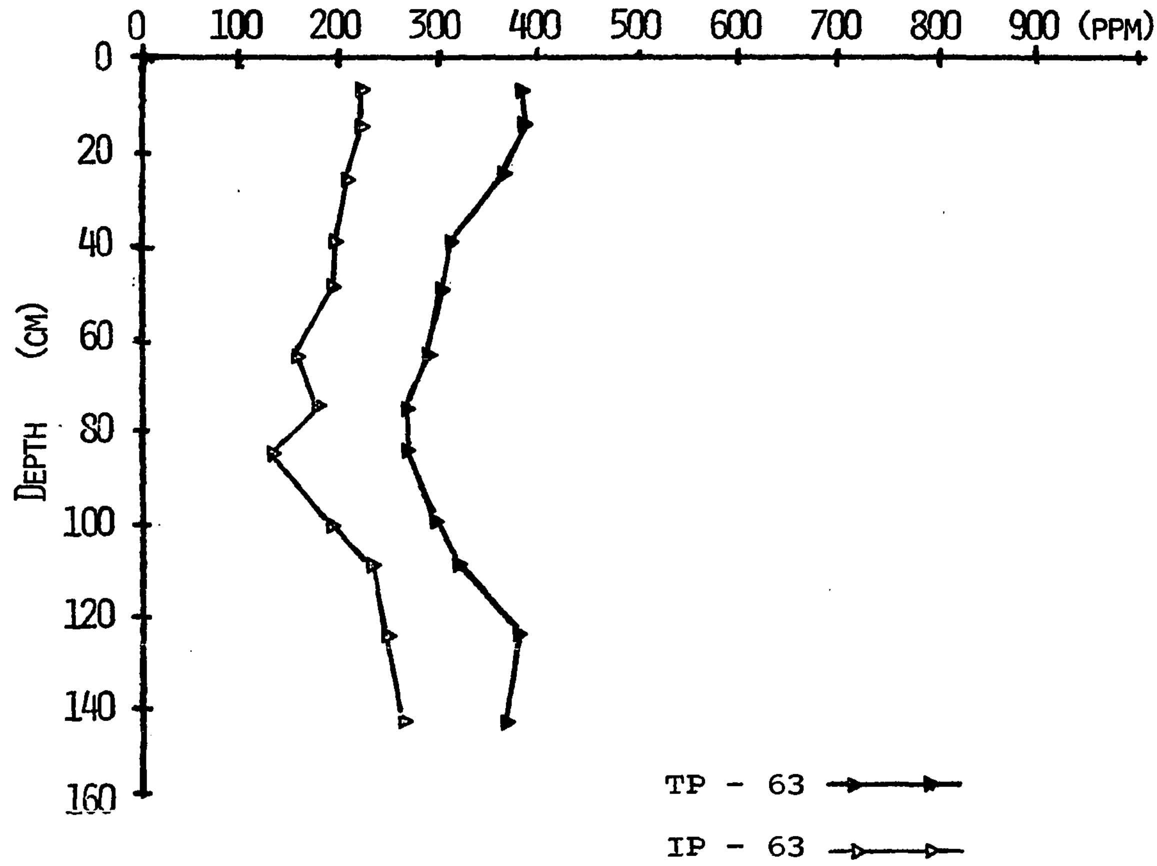


Figure 36. TP and IP depth distribution in soil 63 of the CKL group

Soil 31-1 in FDS group (Figure 37) also had weakly expressed eluviated and illuviated zones of TP and IP. The amount of OP ranged from 42 ppm to 425 ppm.

TP and IP contents may indicate stratification in some profiles such as in soil N4 (Figure 38). Other TP and IP depth distributions may indicate the presence of a buried soil. The TP curve for soil 54 (Figure 39) has two eluviated zones at 28 cm and 114 cm and two illuviated zones at 44 cm and 144 cm. Recent alluvial sediments may have buried a soil at 59 cm.

Bettis (1979) studied TP depth distributions in the development of soils on Indian mounds in northeast Iowa. He reported little movement of phosphorus in the fill of Bluff Top Mound and inferred that the differences in the amount of TP in the fill reflected the original differences in the TP content of soil horizons used to build the mound. TP illuviation and eluviation was evident in soil profiles in transect 1. Bettis concluded that the movement of phosphorus in the soil profile since mound construction was related to soil texture.

The TP depth distribution has also been related to the influence of vegetation on the development of the soil. Typically, forested soils have a higher weighted average TP content in the 0-130 cm than prairie (lowest) or transitional (intermediate) soils (Fenton et al., 1967). These relationships and others mentioned earlier were developed studying upland soils. The relationship of TP and soil genesis has not been investigated to the same degree in

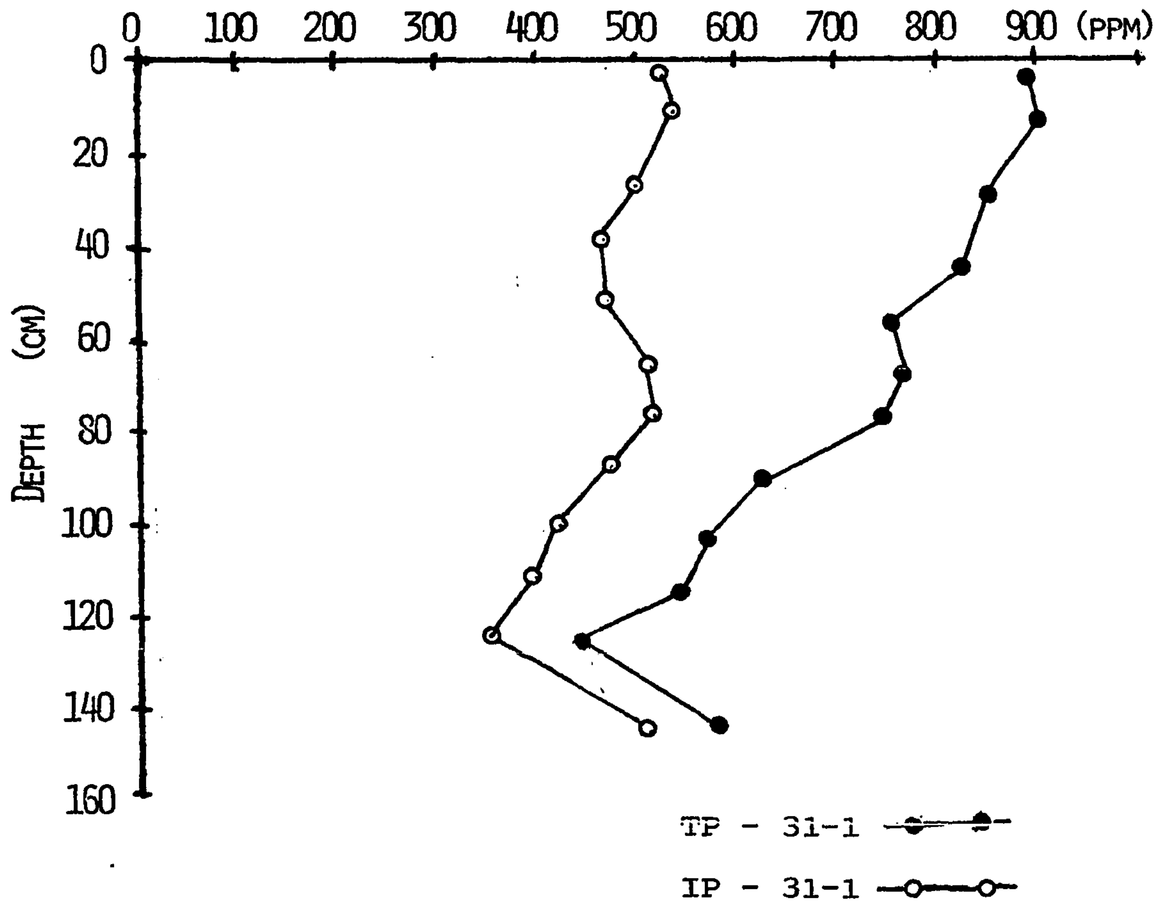


Figure 37. TP and IP depth distribution in soil 31-1 of the FDS group

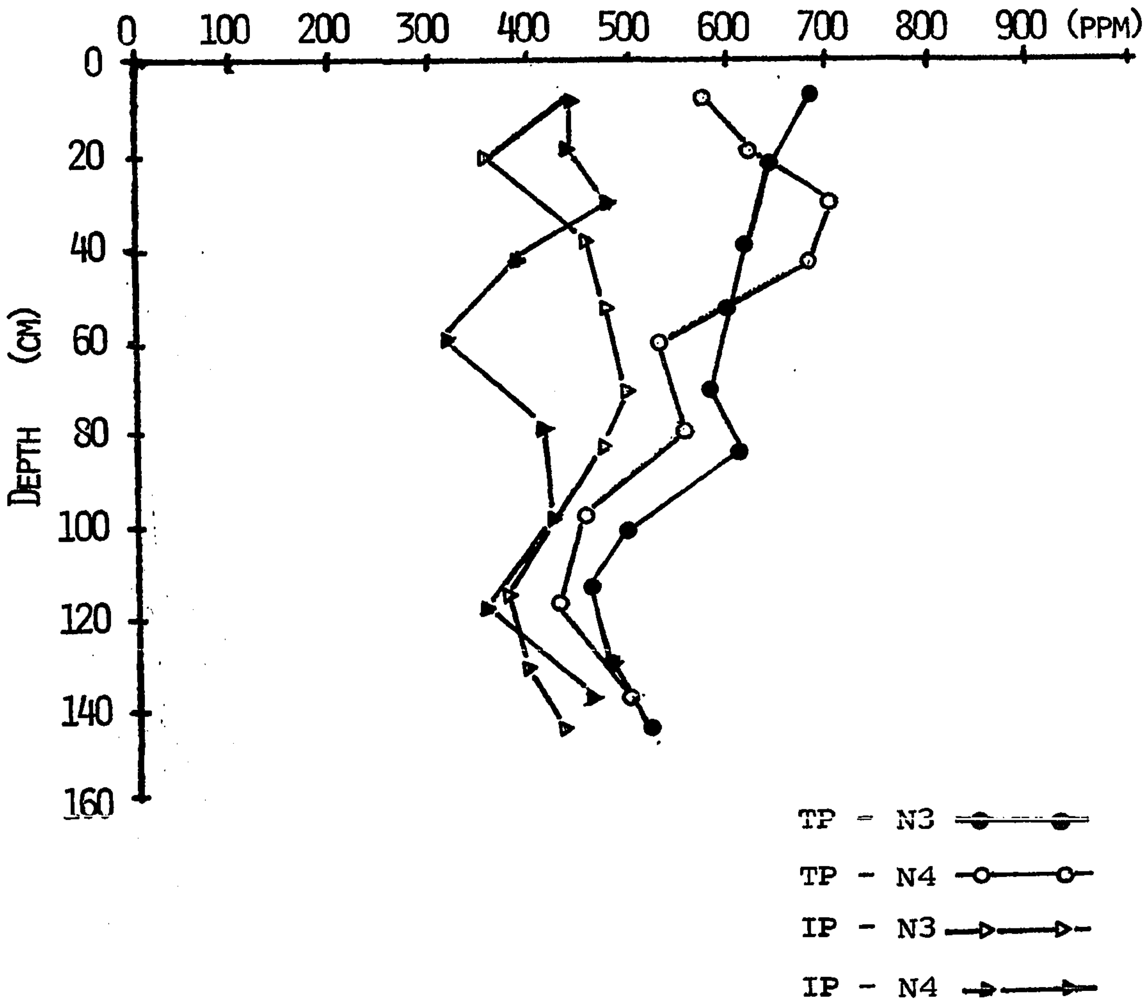


Figure 38. TP and IP depth distribution in Colo soils in NE group

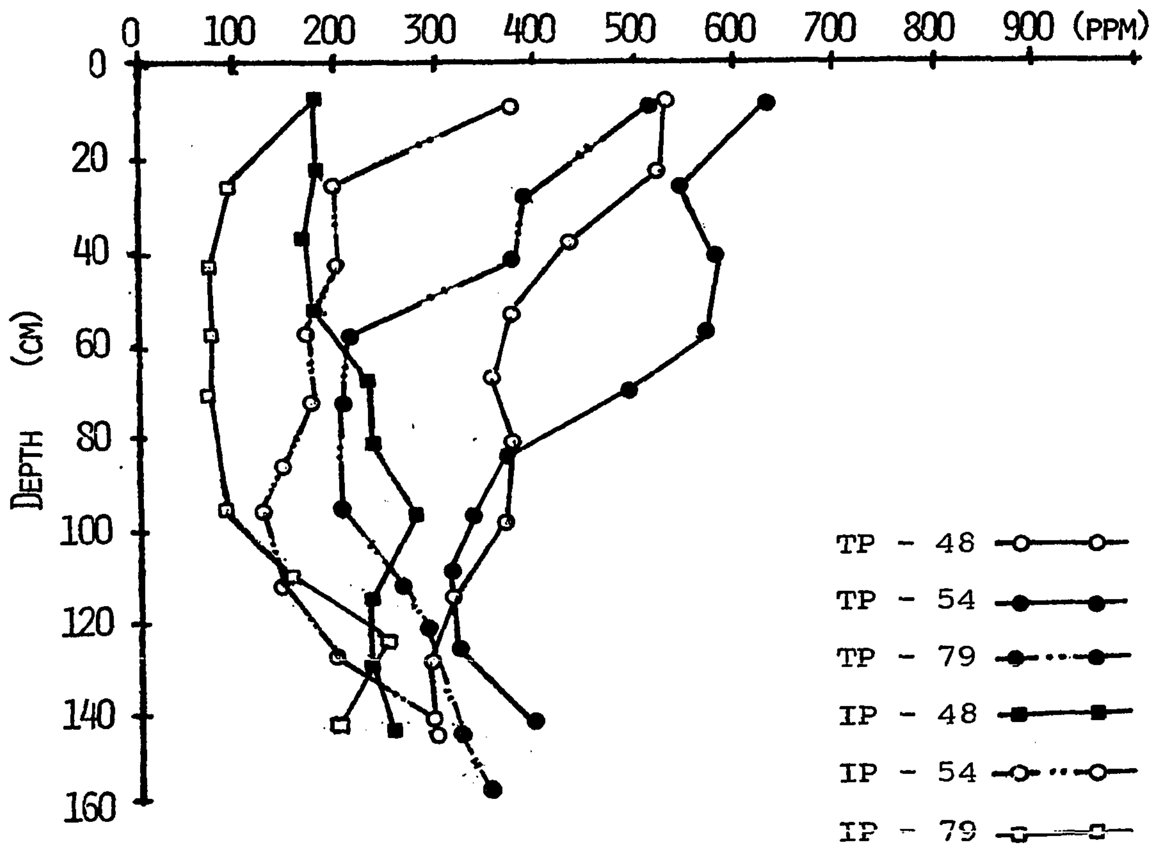


Figure 39. TP and IP depth distribution in Colo soils of OMT group

alluvial-derived soils. The amount and depth distributions for the TM, DT, D, F, and FDS groups are shown in Figures 40, 41, 42, 43, and 37. The weighted averages (Table 11) for these groups are 533 ppm, 596 ppm, 577 ppm, 761 ppm, and 241 ppm, respectively. A trend related to the influence of vegetation on the TP content was not present. Weighted averages (Table 15) calculated for the 0-130 cm depth for the TM, DT, D, F, and FDS groups are 425 ppm, 613 ppm, 636 ppm, 749 ppm, and 726 ppm, respectively. The Colo soils sampled in predominantly forested regions of northeastern Iowa had higher weighted averages in the 0-130 cm zone than the Colo soils collected in predominantly prairie or transitional areas of the state. This is similar to the trend reported by Fenton et al. (1967).

Clay and TP depth distribution have been used in indexing the degree of profile development. Some Colo soils such as soil 60 in the Mo group had well-expressed clay and TP curves. Other Colo soils such as soil 95 in the CNW group had nearly a straight line clay pattern but had well-pronounced eluviated and illuviated TP zones. Soil 63 in the CKL group had nearly straight line clay and TP patterns.

Kosse (1966) studied the application of the organic carbon/organic phosphorus (OC/OP) ratio as a diagnostic index of soil drainage. Several soil profiles from upland prairie soil association areas developed in a variety of parent materials were investigated. He concluded that the OC/OP

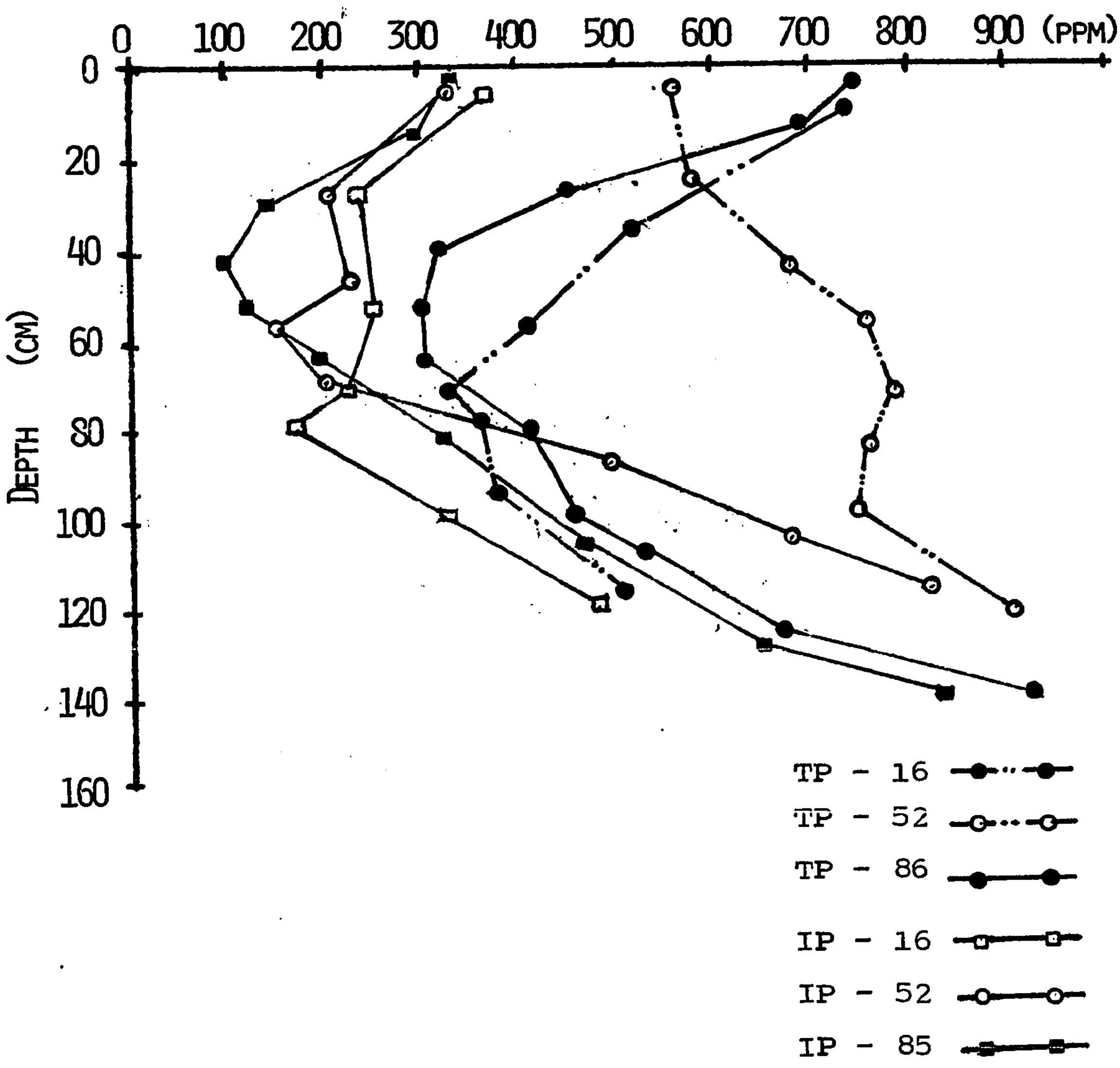


Figure 40. TP and IP depth distribution in Colo soils in TM group

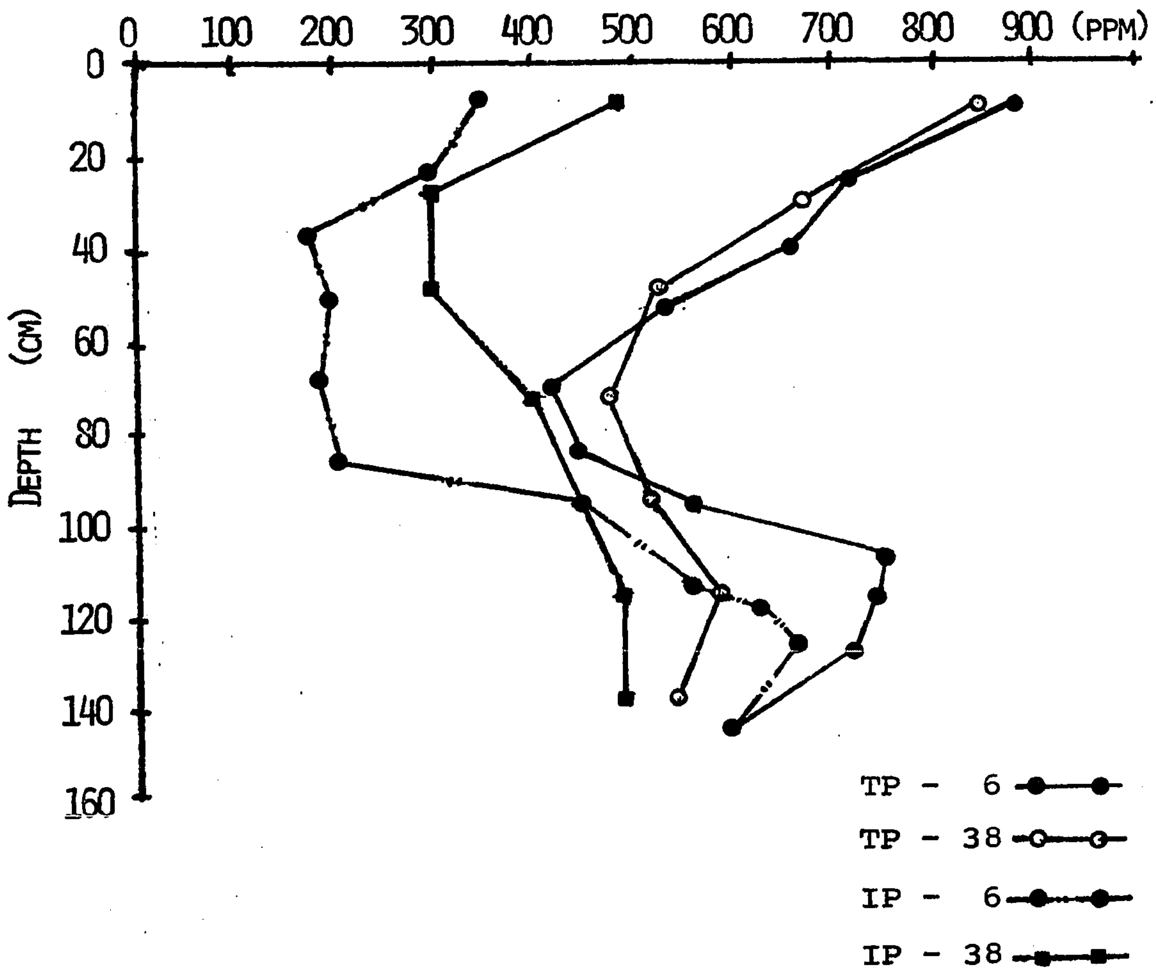


Figure 41. TP and IP depth distribution in Colo soils in DT group

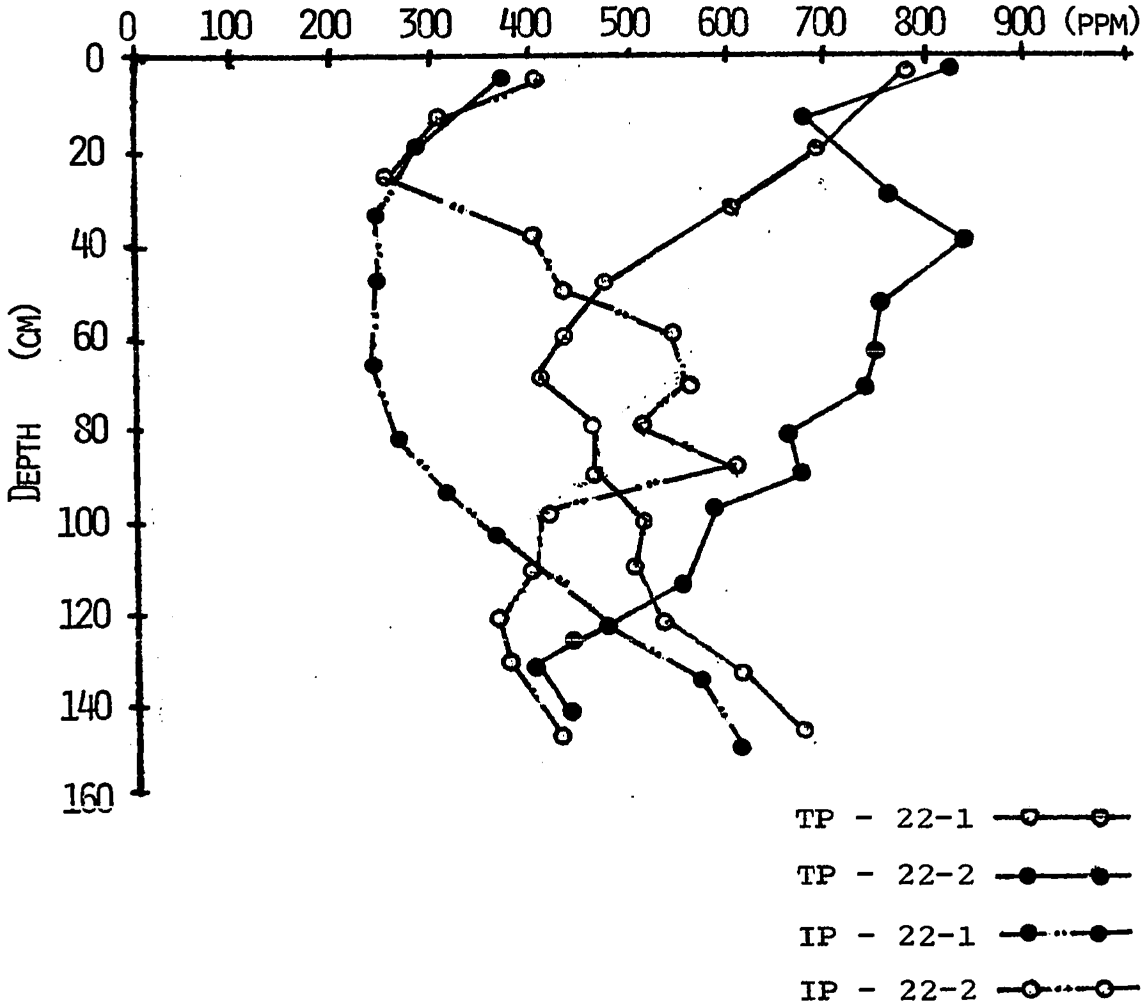


Figure 42. TP and IP depth distribution in Colo soils in D group

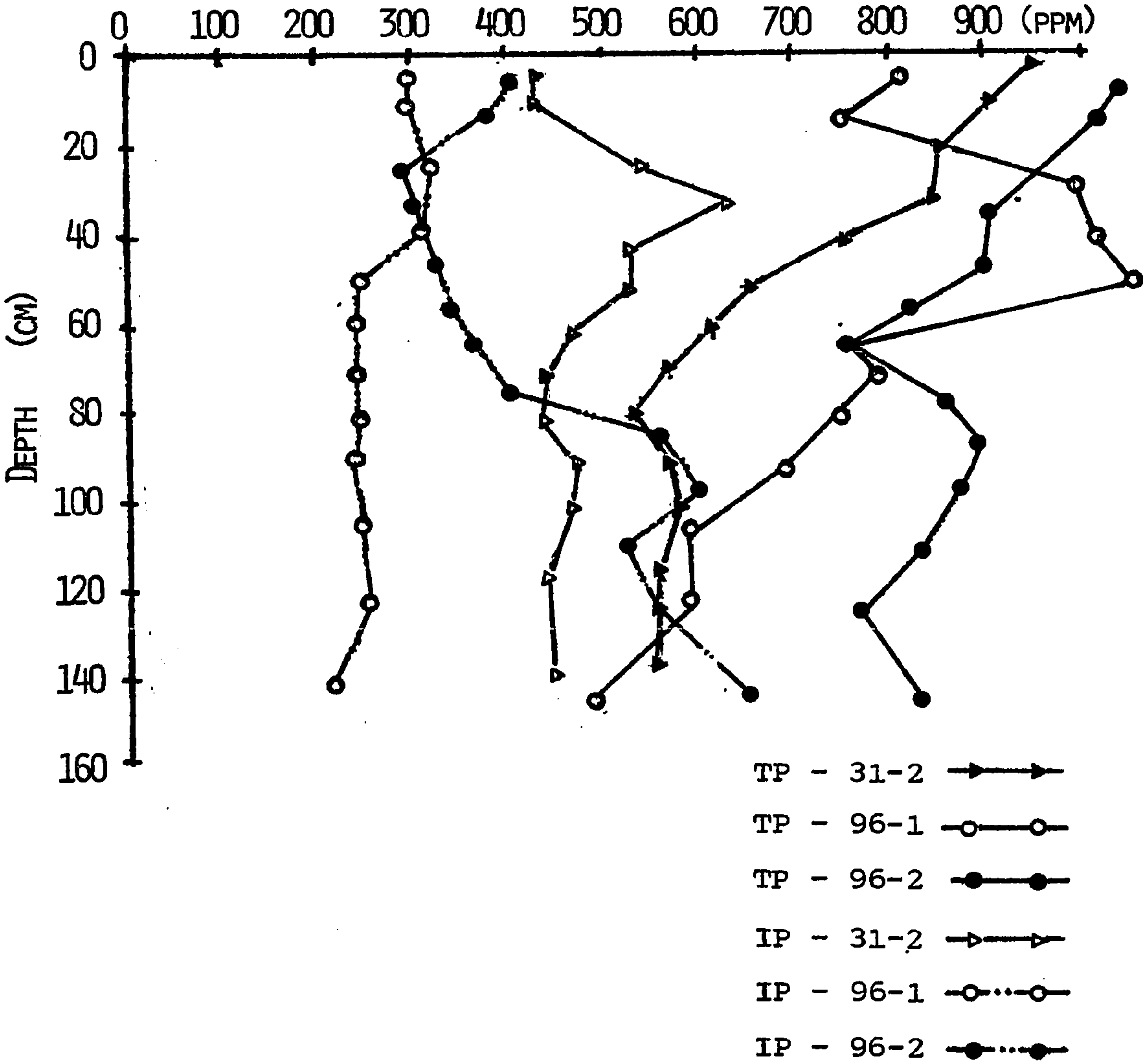


Figure 43. TP and IP depth distribution in Colo soils in F group

ratio may be of value as a relative index of soil drainage within a given drainage sequence independent of parent material. This was especially relevant in certain alluvial-derived soils where time has not been sufficient for subsoil properties to develop or where organic matter has obscured subsoil colors. Higher OC/OP values occurred in poorly drained soils than in the somewhat poorly drained or well- and moderately well-drained soils.

Colo soils are considered to be poorly drained by soil scientists in Iowa but somewhat poorly drained by soil scientists in Nebraska. Also, they are regarded as soils in an early stage of development.

OC/OP ratios for all Colo profiles ranged from 6 to 419 with a mean of 71 and a weighted average of 69 (Table 5). The OC/OP ratio in the NE group ranged from 34 to 231 with a mean of 76 and a weighted average of 69. Therefore, the "somewhat poorly drained" Colo soils had a narrower range but had similar means and weighted averages as the "poorly drained" Colo soils. Kosse (1966) reported that values ranged from 102 to 152 in the poorly drained soils. Generally, the OC/OP ratio was below 100 for many Colo horizon samples and, therefore, does not agree with Kosse's results.

Kosse's OC/OP data were summarized by averaging the reported OC/OP ratio for each horizon of the following soils: Grundy and Haig ((OC/OP) 97), Seymour and Edina (86), Clarion, Nicollet and Webster (108), Galva and Primghar (76), Dinsdale and Tama (67), and Tama and Muscatine (75). The associated Colo groups and averages were GH (55), ASE (51), CNW (151), GPS (73), DT (79), and TM (61) groups. In Kosse's and this study, the OC/OP ratio was highest in the Clarion, Nicollet, and Webster and CNW group.

Generally, OC/OP ratio weighted averages were lower in the groups associated with southern Iowa, Missouri and Illinois than other areas sampled.

Simple correlation coefficients between TP, IP, OP, OC/OP, and OP/TP and other soil analyses

Correlation coefficients (Appendix E) between TP and OP and OP/TP, in the FDS group, were highly correlated (r = .96 and .92, respectively). High r values were calculated for TP and OP (.83), STAVP (.80), STHION (.85), STBHION (.87), and HION (.85) for the Mo group. In GH, NE, and ILL groups, high r values were calculated for TP and other variables.

OP had the highest correlation with OP/TP in the FDS group. Several other variables were highly correlated with OP in other groups. IP was inversely related to OP/TP in the M (-.86), DT (-.84), ILL (-.83), and ASE (-.82) groups. It was highly correlated with OC/OP in MIH group (.84), indicating that as IP content decreases, OC/OP also decreases. OC/OP was highly correlated with the most variables in the ILL group: OP/TP (-.85), STAVP (.88), and STAVK (.89). OP/TP was highly correlated with STBHION in the GH and DT groups (.87 and .82, respectively) and with TK in the Mo and MINN groups (.86

and -.92, respectively).

Total carbon distribution

Total carbon (TC) content was determined on the majority of the Colo soil samples collected for this study. The results of these analyses are in Appendix B. Means, minimum values, maximum values and weighted averages are listed in Table 5 by groups.

Total carbon content is usually reflected in the colors of the soil matrix. For the most part, the Colo profiles had dark colors (N 2/0, 10YR 2/1, 10YR 3/1) to approximately 91 cm which would be expected in a soil that accumulates organic matter. Usually, soils that form under prairie vegetation are characterized by dark colored A horizons. Soils formed under forest vegetation generally have a lighter colored matrix and lower amounts of organic matter in the upper 25 cm than prairie soils.

TC depth distributions for TM, DT, D, F, and FDS groups are presented in Figures 44, 45, and 46. All Colo profiles have a relatively large amount of TC. At 100 cm, only soil 52 in the TM group approaches 0%. Some of the profiles had a lower amount of TC in the upper part of the surface layer than in the lower part. This may be explained by the presence of overwash. Overwash is soil material deposited by the stream when it floods. Generally, it is lower in organic matter than the soil it buries.

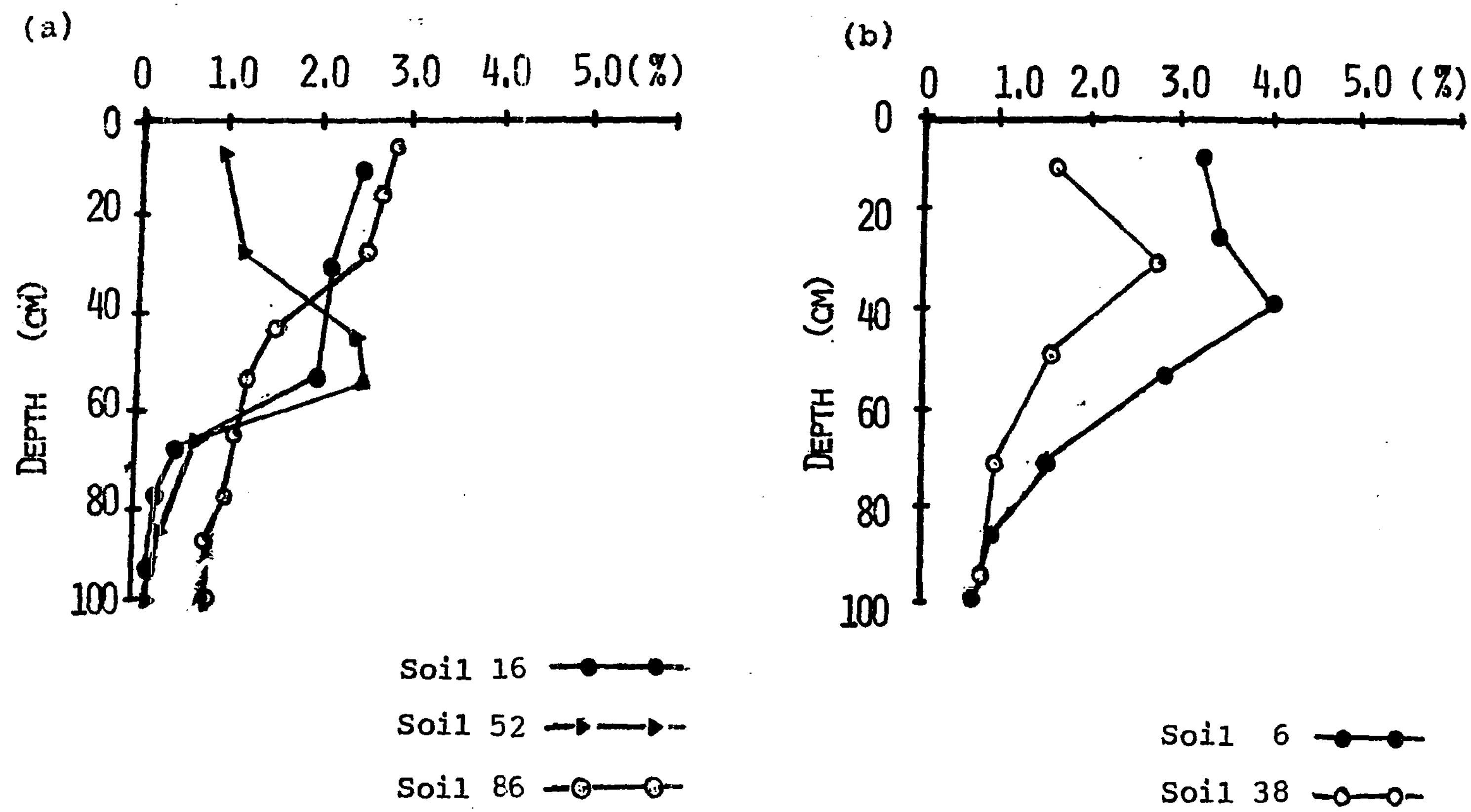


Figure 44. TC depth distribution in Colo soils in (a) TM group and (b) DT group

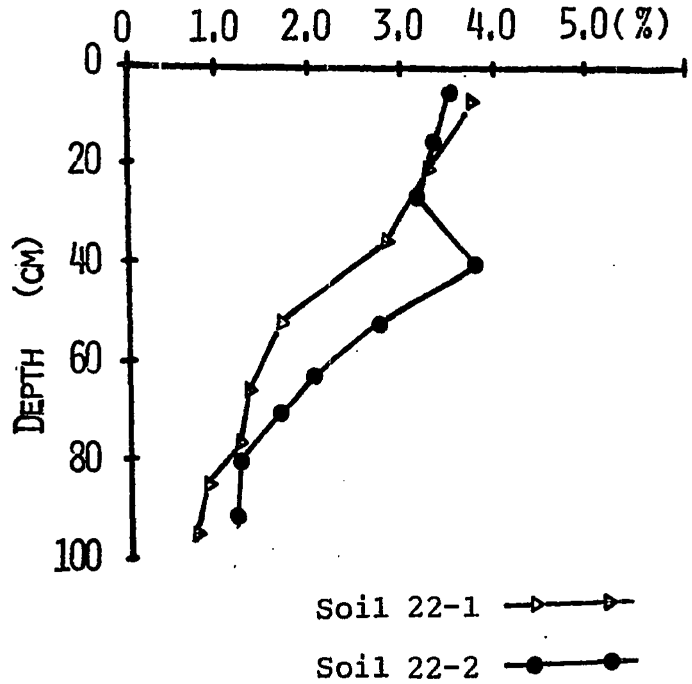


Figure 45. TC depth distribution in Colo soils in D group

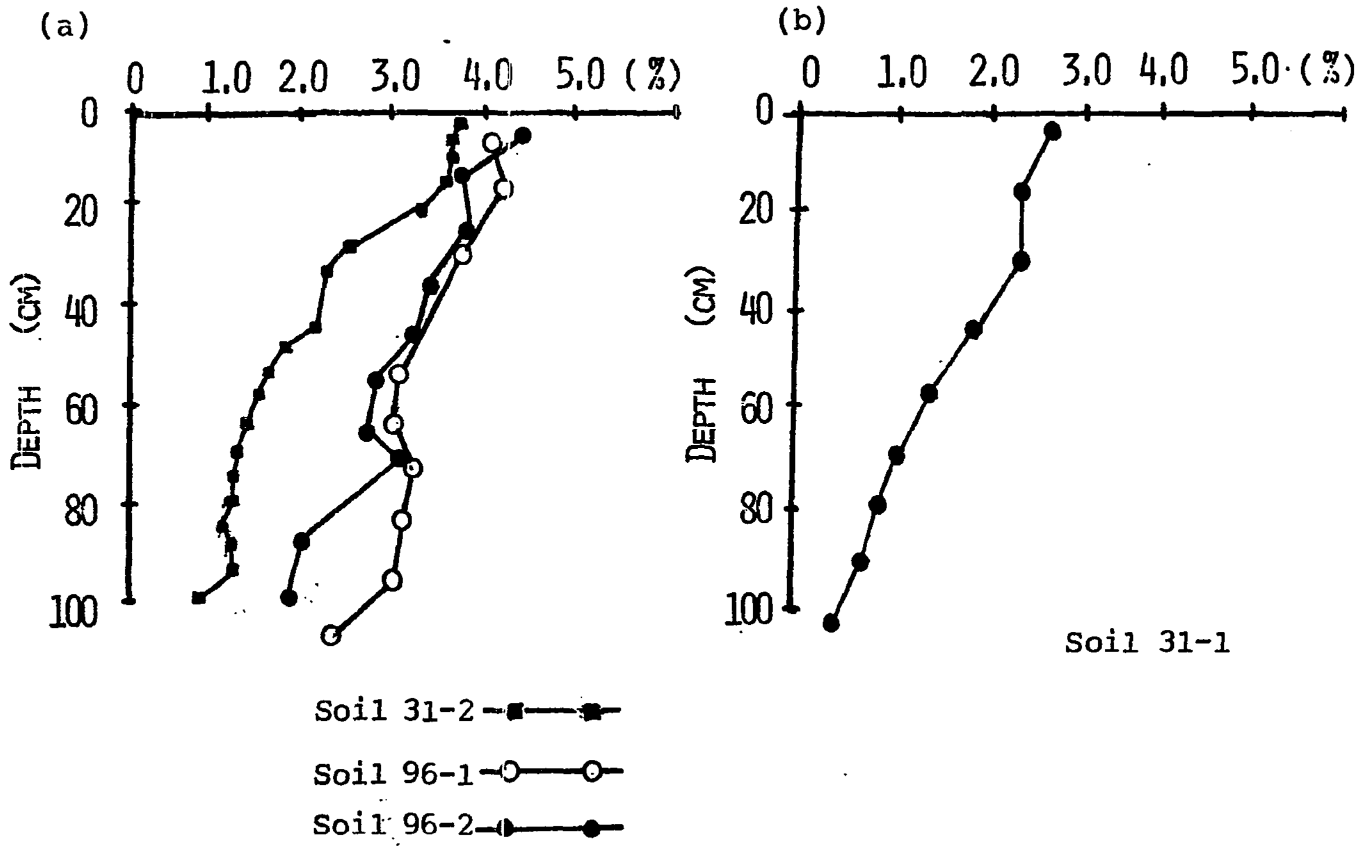


Figure 46. TC depth distribution in Colo soils in (a) F group and (b) FDS group

Weighted averages for the TC content in the Colo profiles by groups are presented in Table 11. The highest group weighted average was calculated for the F group (2.5%) and the lowest weighted average was for the MISSO group (.8%). A trend to determine the influence of vegetation on the soils genesis was not shown by the TC weighted averages for the entire profile. The TC content in the sediments may be low if the source of the sediment comes from soils formed under forest vegetation which usually are low in TC. This was not the case. As shown in Figures 44a and 45, the surface layer of the Colo soils in the D group (transitional) had a higher content of TC than the surface layer in the Colo soils in the TM group (prairie).

The TC content may also be affected by the soil temperature and soil moisture. Organic matter will generally decompose quickly in a warm soil environment. The influence of temperature on organic matter decomposition can best be explained by quoting Van Hoff's temperature rule, "For every $10^{o}C$ rise in temperature, the speed of a chemical reaction increases by a factor of two to three" (Buol et al., 1973).

Soil moisture is an important factor in the formation of soil. It is also necessary for the growth of flora and fauna that contribute organic material to the soil. If soil moisture is deficient, flora and fauna may be curtailed. However, if the soil is saturated for long periods of time, the rate of organic matter decomposition is greatly reduced. The soil in a saturated condition also warms more slowly in the spring and cools more rapidly in the fall.

Colo soil samples were collected in several counties which varied in soil temperature and soil moisture. Lafayette County, Missouri, where sample M2 was collected, is just north of the thermic-mesic soil temperature boundary (Figure 1). Dakota County, Minnesota, where sample MINN2 was collected, is just south of the mesic-frigid soil temperature boundary. Soil moisture increases from eastern Nebraska to eastern Illinois. This is illustrated by the soils which are classified as Ustolls or Ustic Udolls in eastern Nebraska and Udolls in Illinois (Figure 1). Precipitation also increases from eastern Nebraska to eastern Illinois as indicated by a yearly rainfall average of 67 cm in Cuming County, Nebraska to a yearly rainfall average of 91 cm in the Champaign-Urbana area.

Plotted in Figures 47 and 48 are the TC depth distribution for the NE, MISSO, ILL, and MINN groups. Comparing the TC patterns for MISSO and MINN groups, it is obvious that the MISSO group has less TC than the MINN group.

TC in NE and ILL groups ranged from .5% to 2.5% and .9% to 2.5%, respectively. Means and weighted averages were 1.4% and 1.8% for the NE group and 1.7% and 1.5% for the ILL group. Soils N1 and N4 seem to have approximately 42 cm of overwash that is low in TC (Figure 47a). If TC values for soils N1 and N4 were eliminated from the calculations, the

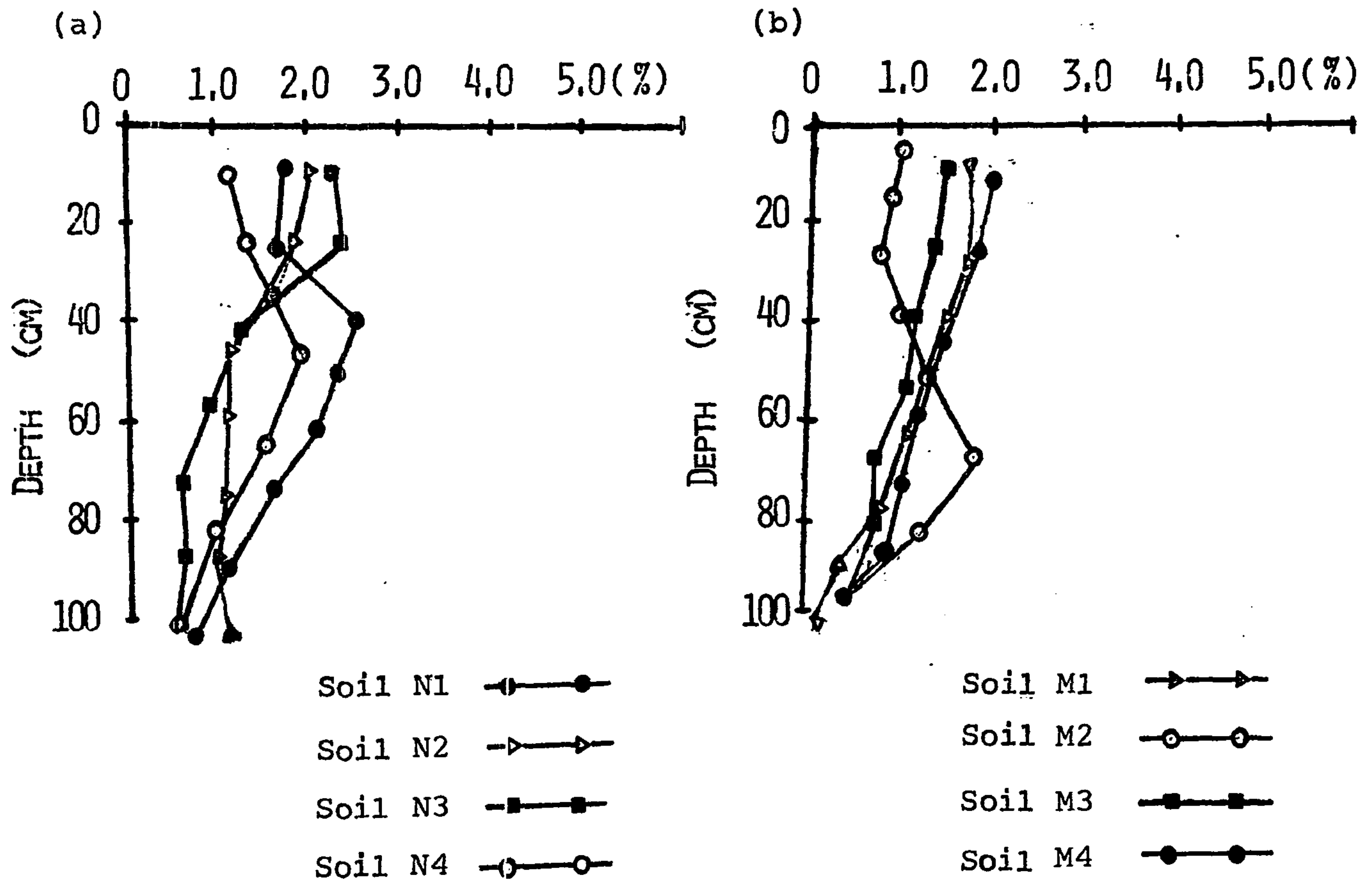


Figure 47. TC depth distribution in Colo soils in the (a) NE group and (b) MISSO group

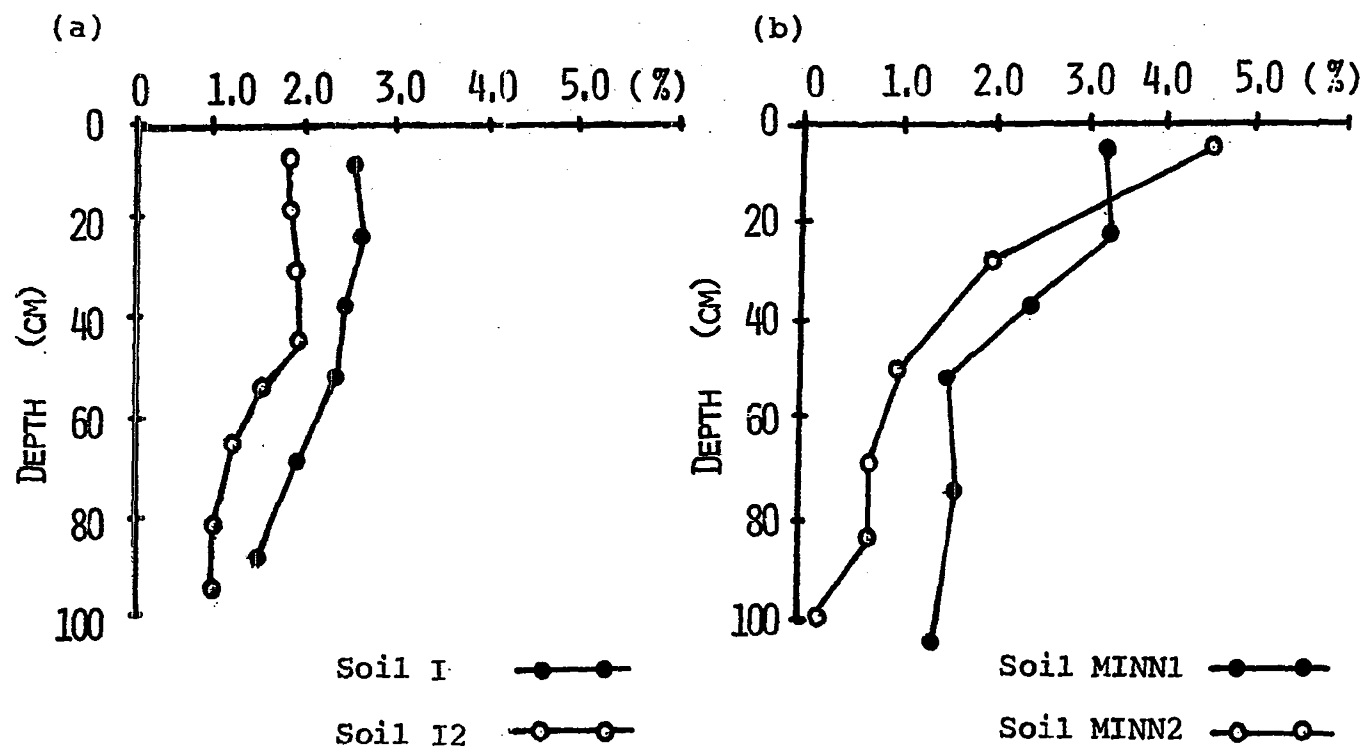


Figure 48. TC depth distribution in Colo soils in (a) ILL group and (b) MINN group

mean would have been 1.3%. The TC content in the ILL group decreased less with depth than the TC content in the N2 and N3 soils. Below approximately 42 cm, the patterns for the N1 and N4 soils in the NE group were similar to the pattern in the ILL group.

In general, the highest means and weighted averages of TC content were calculated for groups located in northeastern Iowa. The mean and weighted average for the D group were 2.2% and 2.3%, respectively. The F group had a mean and weighted average of 2.4% and 2.5%, respectively.

Simple correlation coefficients between TC and other soil variables

Higher values were computed between TC and several chemical and physical soil variables in different groups (Appendix E). Two of the higher r values were between silt and TC (CKL group) and clay and TC (GH group).

Total and available potassium distribution

Total potassium (TK)[1] content was determined on selected samples of the Colo profiles. Available potassium (STAVK) content was analyzed by the Iowa Soil Testing Laboratory for

[1]Usually, TK is determined on the <.001 mm clay fraction in soils. In this study, TK was analyzed on the <.002 mm clay fraction. A study was done by the author to determine if the results are comparable. This study indicated that use of the <.002 mm clay fraction gives results that are similar to those obtained by use of the <.001 mm clay fraction.

some of the Colo soils. The results from these analyses are presented in Appendix B. Means, minimum values, maximum values, and weighted averages were calculated to determine if a regional or local trend existed (Table 11).

The extreme northwestern Iowa group (Mo) had a weighted average TK content of 1.1%. This was lower than the values reported by Wells (1963) and Kovar (1967) for principal upland soils in northwestern Iowa. TK weighted averages in the western Iowa Colo groups were 1.4% (MIH), 1.5% (M), and 1.5% (SSM). TK weighted averages in eastern Iowa were 1.4% (CKL), 1.6% (OMT), and 1.4% (GH).

Climatic effects and TK contents relationships as discussed by Wells (1963) and Kovar (1967) were not apparent in the Colo groups.

Wells (1963) studied the relationship between potassium (K) and the stages of soil development. He concluded that in the loess-derived, prairie-upland soil areas, a climatic effect was operative which was related to degree and not kind of weathering. Soil samples of <.001 mm fraction of the B horizon were analyzed in his study. The K content gradually decreased eastward as average annual rainfall fradually increased from Nebraska to Illinois. Mineralogically, the peak of 10 Å clay minerals in the <.001 mm fraction decreased eastward along with a corresponding increase in peak heights of the 17 Å clay minerals. Wells concluded that the peak heights of 10 Å and 17 Å clay minerals were related to K content and inversely related to each other. He interpreted the results as indicating that the primary source of K was micaceous clay minerals. As these clay minerals weathered, K was lost and montmorillonite clay minerals were formed.

TK content in the Colo groups was low in low rainfall areas (weighted average .8%, NE group) and high in high rainfall areas (weighted average 1.8%, ILL group). Clay mineralogy as determined by x-ray diffraction may explain the low content of TK in the NE group and high amount in the ILL group. This relationship will be discussed later.

The weighted averages of the TM, D, and F groups, 1.3, 1.6, and 1.4%, respectively, are similar to the trend noted by Kovar (1967).

Kovar (1967) determined the TK average of the upper three horizons in thick loess, poorly drained eastern Iowa soils and reported the transitional soils had the highest TK average. Forested soils had intermediate amounts, while prairie soils had the lowest amount of TK. Profile development has also been associated with TK depth distributions. Within limits of this study, TK would not be considered a good indicator of profile development or horizon differentiation in alluvial-derived soils. Kovar (1967) reported that the Sac (thin loess/till) and related soils of northwestern Iowa were less developed, had higher nonexchangeable K content, and had higher illite content than the Dinsdale (thin loess/till) and related soils of eastern Iowa. He attributed the differences to the less weathered conditions of the northwestern Iowa soils which was probably due to lower annual precipitation in that area.

The TK content in soils is of little value as an index to the availability of K to plants. Therefore, STAVK or in some cases exchangeable K is used as an index in determining the amount of K in the soil which can be used by plants. Table 16 presents STAVK data calculated in the same way as the AVP data in Table 14 except that the 30-61 cm zone was used instead of 76-107 cm. All Colo profiles had greater amounts of STAVK in the 0-20 cm zone than in the 30-61 cm zone. This was also true for the principal upland soils in each group. The principal upland soils in western Iowa had considerably higher amounts of STAVK than the principal upland soils in eastern Iowa.

In western Iowa soil fertility soil association areas, excluding the Luton-Onawa-Salix area, the average STAVK content for the plow layer exceeded 150 ppm. In eastern Iowa, the highest average STAVK amount for a soil fertility soil association area was 113 ppm for the plow layer (Eik, 1980).

The amount of STAVK may depend on the kind and amount of clay minerals present in the soil. K in kaolinite and montmorillonite is readily exchangeable (located on exchange sites) with the soil solution for uptake by plants while much of the K in illite and vermiculite is not exchangeable, being firmly

Table 16. Comparison of STAVK content for different depths as determined by Iowa Soil Testing Laboratory, Collins, and for statistical study

	Principal upland soil		Colo soil	
	STD[a]	SS[b]	STL[c]	
Soil	0-≈20 cm	30-61 cm	0-20 cm	30-61 cm
	ppm			
Mo group				
60	175	26	319	50
Average	175	26	319	50
GPS group				
75	179	21	95	22
71	176	19	-	-
18	181	19	-	-
21	133	25	86	26
81	174	20	81	22
Average	169	21	87	23
MIH group				
97	183	21	240	69
43	172	42	174	40
Average	178	32	207	55
M group				
5	177	56	-	-
36	174	52	139	30
24	177	26	-	-
Average	176	47	139	30
SSM group				
1	84	45	85	27
88	167	45	125	26
73	168	42	75	20
Average	140	44	95	24

[a]Soil Testing data (Eik, 1980).

[b]Statistical study.

[c]Colo soils analyzed by Soil Testing Laboratory (STAVK).

Table 16. (Continued)

Soil	Principal upland soil: STD 0–≈20 cm	Principal upland soil: SS 30–61 cm	Colo soil: STL 0–20 cm	Colo soil: STL 30–61 cm
	ppm			
ASE group				
4	106	26	-	-
Average	106	26	-	-
CKL group				
63	100	27	74	28
Average	100	27	74	28
OMT group				
62	114	42	-	-
44	112	45	195	32
29	112	45	178	40
79	117	26	-	-
48	117	26	63	19
54	117	26	-	-
Average	115	35	145	30
GH group				
56	98	31	63	21
Average	98	31	63	21
TM group				
86	128	26	56	19
16	133	26	-	-
52	133	26	97	27
Average	131	26	77	23
DT group				
38	133	26	-	-
6	147	24	86	28
Average	140	25	86	28
FD group				
31-1	101	31	-	-
Average	101	31	-	-

Table 16. (Continued)

	Principal upland soil		Colo soil	
	STD	SS	STL	
Soil	0-≈20 cm	30-61 cm	0-20 cm	30-61 cm
	ppm			
D group				
22-1	108	26	435	50
22-2	108	26	-	-
Average	108	26	435	50
F group				
96-1	96	21	-	-
96-2	90	35	-	-
31-2	101	26	197	34
Average	96	27	197	34
CNW group				
95	199	26	36.5[d]	11[e]
Average	199	26	36.5	11
NE group				
N1	-	-	-	-
N2	-	-	122	38
N3	-	-	-	-
N4	-	-	-	-
Average	-	-	122	38
MISSO group				
M1	-	-	-	-
M2	-	-	-	-
M3	-	-	97	22
M4	-	-	57	19
Average	-	-	77	21

[d] 0-5 cm and 15-20 cm.

[e] 30-35 cm, 45-50 cm, and 60-61 cm.

Table 16. (Continued)

Soil	Principal upland soil STD 0–≈20 cm	Principal upland soil SS 30–61 cm	Colo soil STL 0–20 cm	Colo soil STL 30–61 cm
	ppm			
ILL group				
I	–	–	–	–
I2	–	–	57	26
Average	–	–	57	26
MINN group				
MINN1	–	–	79	15
MINN2	–	–	30	19
Average	–	–	55	17

adsorbed in nonexpandable interlayer positions.

Subsoil amounts were similar between principal upland soils and Colo soils in the following groups: GPS, CKL, OMT, TM, and DT. Amounts of STAVK in the subsoil were greater in the principal upland soils in the SSM and M groups than other groups but the Colo SSM and M groups had intermediate amounts. Ghaffarzadeh (1979) reported similar trends in loess-derived soils. The Marshall, Sharpsburg, and Macksburg soils had the highest available K subsoil values.

The subsoil STAVK values varied among and within the Colo soil profiles which is similar to results reported by Drs. L. C. Dumenil, T. E. Fenton, and F. F. Riecken (Department of Agronomy, Iowa State University, unpublished data).

STAVK patterns are illustrated in Figures 49 and 50. Most of the STAVK depth distributions in the Colo soils were similar. The greatest amount of STAVK was in the surface layer, then STAVK sharply decreased to the minimum between 40 to 60 cm. STAVK content remained relatively constant with depth below the 40 to 60 cm depth. In some soils there was a slight increase in the lower portion of the profile.

In eastern Iowa, the D group (Figure 50b) had one of the highest amounts of subsoil STAVK. The F group (Figure 50b) had an intermediate amount while the TM group (Figure 50a) had the lowest amount. Ghaffarzadeh (1979) reported that the loess-derived prairie soils in eastern Iowa had higher subsoil STAVK levels than the forest soils. He also stated that the alluvium-derived soils in eastern Iowa had much less subsoil STAVK than those in western Iowa. The Colo soils in the Mo group had higher subsoil STAVK than the Colo soils in the TM, DT, F, and ILL groups. However, the D group in northeastern Iowa had the same amount of subsoil STAVK as the Mo group in northwestern Iowa.

Model Development for Evaluating the Genesis of Soils Derived in Alluvial Sediments

One of the objectives of this study was to develop a model to enable a better understanding of the genesis of soils derived in alluvial sediments in the NCR. As stated earlier, models are used to help understand soil processes within some

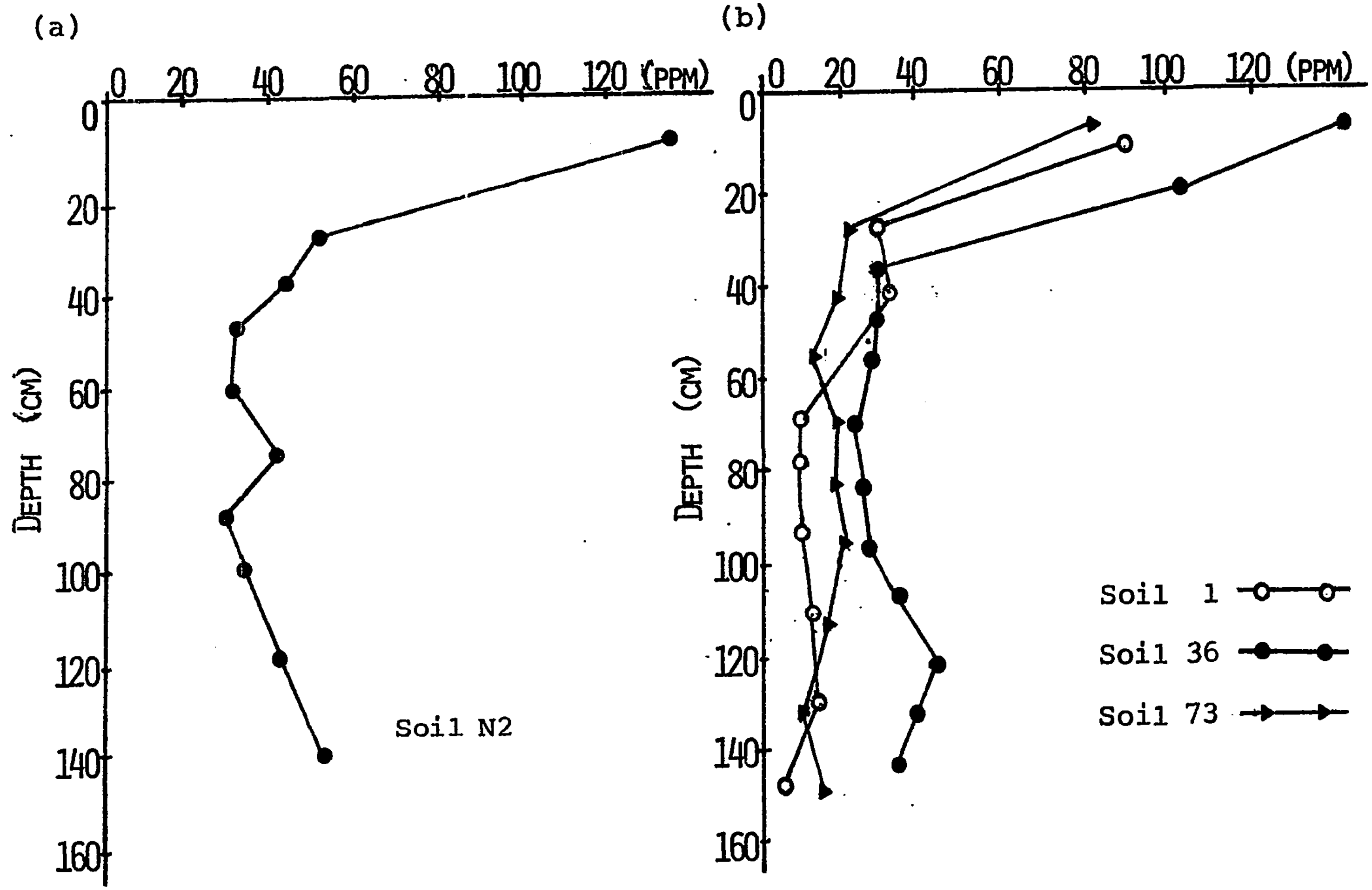


Figure 49. STAVK depth distribution in Colo soils in the (a) NE group and (b) M and SSM groups

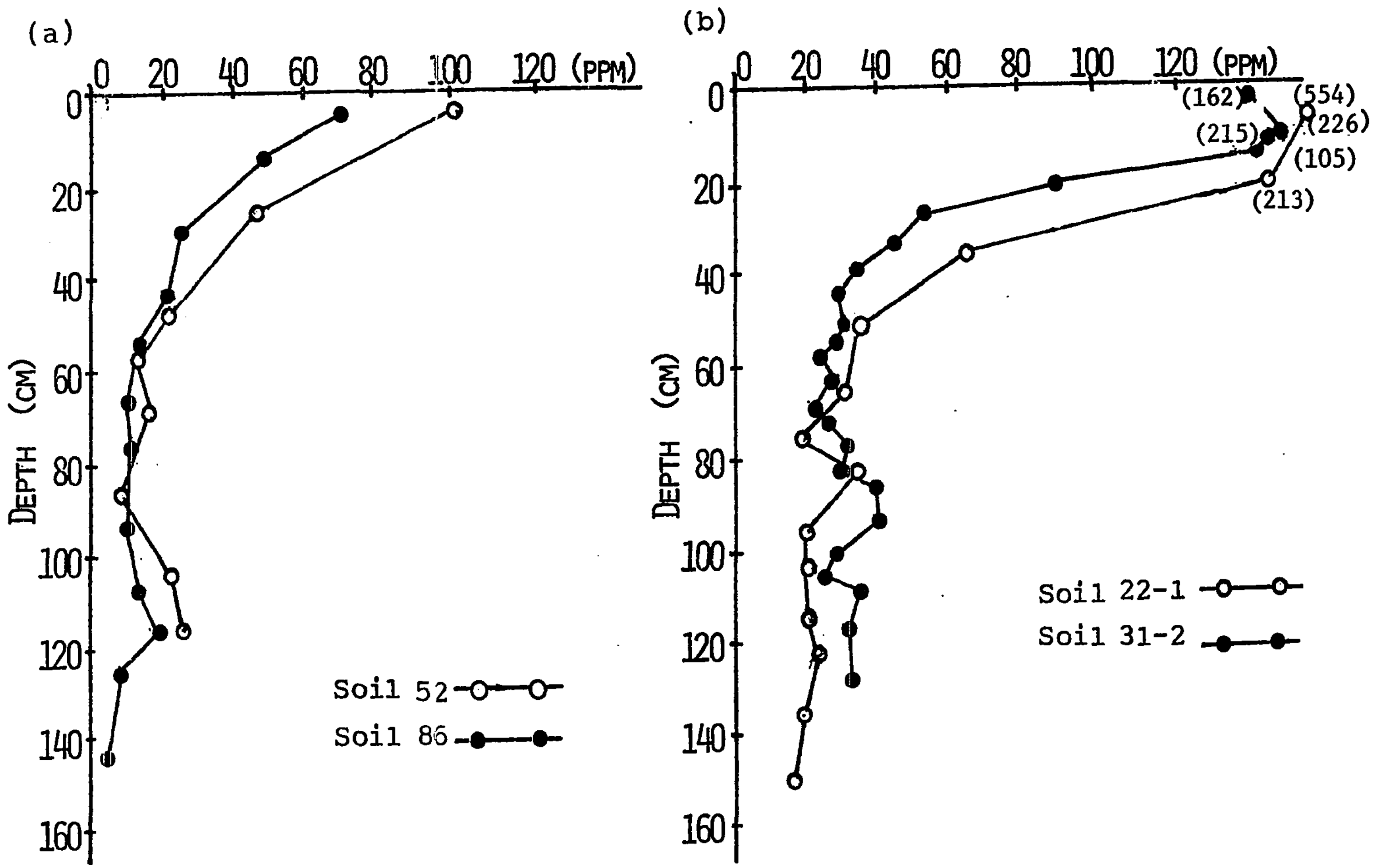


Figure 50. STAVK depth distribution in Colo soils in (a) TM group and (b) D and F groups

"realm of possibility" or probability. As more knowledge is accumulated, models will help explain the relationships between data and the real soil system.

Mathematical models have been used to predict soil properties and the relationship between these properties and the soil environment. Such studies used major principal upland soils on relatively stable landscape positions. Coleman (1980) recently used mathematical equations to predict various properties of loess-derived soils and the depth to the perched groundwater table for summits and less stable side-slopes in southern Iowa. Mathematical equations or statistical models have not been utilized as much in studying the properties of alluvial-derived soils. One reason may be because the parent material of alluvial-derived soils was considered to be initially heterogeneous in nature. Upland soils, especially those formed in loess, initially had a homogeneous parent material. This made modeling the genesis of soils developed in loess parent material an easier task. In soils derived from alluvial sediments, some soil properties may be the result of pedogenesis or the result of sedimentation. Distinguishing between these processes is difficult because they may overlap.

Descriptive modeling equations were developed for the chemical, physical, mineralogical, and landscape parameters of the Colo soils.

Modeling equations for chemical and physical properties

Modeling equations describing the chemical and physical properties of Colo soils are presented in Table 17.

The samples used in modeling these soil variables included (1) All Profiles, (2) Colo soils in MISSO, TM, FDS, OMT, and NE groups combined, and (3) Colo soils in MISSO, TM, FDS, OMT, and NE groups as individual groups. The intent of this study was to model several soil properties or variables in prediction equations. Clay content, TP, AVP, and HION were selected as dependent and independent variables. These soil variables were selected because they provide an important function in determining the stage of soil profile development. Other researchers have used these soil variables as indicators of the soil's genesis.

The models were limited by the maximum depth that TC was determined. In most profiles this depth was approximately 100 cm. Therefore, these modeling equations indicate the relationships between and among the soil variables to approximately 100 cm. Surface horizon samples were included. Groups MISSO, TM, FDS, OMT, and NE were selected because these Colo groups had the largest number of samples analyzed for the soil variables mentioned. They were not selected to represent an area of the state, even though they do, but rather, to determine trends within the soil profile and among soil profiles.

The highest R^2 value for All Profiles group was with the model: TP = TC*AVP*HION*CLAY (.53) (Table 17). Low R^2 values

Table 17. Model equations of selected physical and chemical properties

Group	Model equations	R^2
All profiles (282 samples)	TC = TP[a]	.30**[b]
	= TP*AVP	.34**
	= TP*AVP*CLAY	.35**
	= TP*AVP*CLAY*HION	.35**
	TC = -.478 + .016CLAY + .003TP - .012AVP + 72435.77HION	
	AVP = TP	.29**
	= TP*HION	.38**
	= TP*HION*TC	.42**
	= TP*HION*TC*CLAY	.42**
	AVP = -5.848 - .117CLAY - 4.976TC + 0.668TP + 6017595.44HION	
	HION = AVP	.14**
	= AVP*TP	.15**
	= AVP*TP*TC	.16**
	= AVP*TP*TC*CLAY	.16**
	HION = $1.3\text{x}10^{-8}$ + $1.0\text{x}10^{-8}$CLAY + $1.2\text{x}10^{-7}$TC + $2.0\text{x}10^{-8}$AVP - $.0\text{x}10^{-8}$TP[c]	
	CLAY = TC	.02*
	= TC*HION	.02++
	= TC*HION*AVP	.02
	= TC*HION*AVP*TP	.02
	CLAY = 31.626 + .640TC + .00018TP - .012AVP + 340442.29HION	
	TP = TC	.30**
	= TC*AVP	.52**
	= TC*AVP*HION	.53**
	= TC*AVP*HION*CLAY	.53**
	TP = 294.33 + .130CLAY + 97.88TC + 4.748AVP - 16805729.81HION	

[a]Variables are added to the model equation.

[b]**,*,++Significance at the 1%, 5%, and 10% levels, respectively, in this and all other tables.

[c]Number too small for computer to print.

Table 17. (Continued)

Group	Model equations	R^2
MISSO, TM, FDS, OMT, and NE groups combined (123 samples)	TC = TP	.34**
	= TP*AVP	.48**
	= TP*AVP*CLAY	.50**
	= TP*AVP*CLAY*HION	.50**
	TC = .763 - .028CLAY + .004TP - .019AVP + 27063.19HION	
	AVP = TP	.25**
	= TP*TC	.39**
	= TP*TC*CLAY	.43**
	= TP*TC*CLAY*HION	.43**
	AVP = 24.08 - .929CLAY - 10.99TC + .088TP + 1004633.85HION	
	HION = CLAY	.005**
	= CLAY*AVP	.01**
	= CLAY*AVP*TC	.01**
	= CLAY*AVP*TC*TP	.01**
	HION = $2.5\text{x}10^{-7} + 2.0\text{x}10^{-8}$CLAY + $7.0\text{x}10^{-8}$TC + $.0\text{x}10^{-8}$AVP - $.0\text{x}10^{-8}$TP	
	CLAY = AVP	.02
	= AVP*TP	.05++
	= AVP*TP*TC	.08**
	= AVP*TP*TC*HION	.09**
	CLAY = 30.33 - 1.349TC + .010TP - .077AVP + 345903.11HION	
	TP = TC	.40**
	= TC*AVP	.61**
	= TC*AVP*CLAY	.64**
	= TC*AVP*CLAY*HION	.64**
	TP = 20.22 + 6.608CLAY + 125.57TC + 4.760AVP - 2143213.28HION	

Table 17. (Continued)

Group	Model equations	R^2
MISSO (30 samples)	TC = TP	.13*
	= TP*HION	.27*
	= TP*HION*AVP	.36**
	= TP*HION*AVP*CLAY	.36*
	TC = .257 + .011CLAY + .002TP - .011AVP - 279923.82HION	
	AVP = TP	.47**
	= TP*CLAY	.54**
	= TP*CLAY*TC	.58**
	= TP*CLAY*TC*HION	.59**
	AVP = 14.259 - .661CLAY - 9.720TC + .098TP - 3428135.10HION	
	HION = CLAY	.56**
	= CLAY*TC	.60**
	= CLAY*TC*TP	.63**
	= CLAY*TC*TP*AVP	.64**
	HION = $-2.9\times10^{-6} + 1.2\times10^{-7}$CLAY $- 5.9\times10^{-7}$TC $- 1.0\times10^{-8}$AVP $+ .0\times10^{-8}$TP	
	CLAY = HION	.56**
	= HION*AVP	.58**
	= HION*AVP*TC	.59**
	= HION*AVP*TC*TP	.59**
	CLAY = 27.946 + 747TC + .002TP - .052AVP + 4009972.73HION	
	TP = AVP	.47**
	= AVP*TC	.55**
	= AVP*TC*HION	.66**
	= AVP*TC*HION*CLAY	.66**
	TP = 99.577 + 1.260CLAY + 119.859TC + 5.732AVP + 50329588.59HION	

Table 17. (Continued)

Group	Model equations	R^2
TM (18 samples)	TC = HION	.22*
	= HION*TP	.48**
	= HION*TP*AVP	.67**
	= HION*TP*AVP*CLAY	.67**
	TC = −.949 + .0004CLAY + .005TP − .042AVP + 696600.08HION	
	AVP = TP	.48**
	= TP*TC	.66**
	= TP*TC*HION	.69**
	= TP*TC*HION*CLAY	.69**
	AVP = −10.902 − .011CLAY − 8.925TC + .073TP + 4597238.17HION	
	HION = TC	.22**
	= TC*TP	.44**
	= TC*TP*AVP	.49**
	= TC*TP*AVP*CLAY	.51**
	HION = $9.5\text{x}10^{-7} + 2.0\text{x}10^{-8}\text{CLAY} + 6.0\text{x}10^{-7}\text{TC} + 2.0\text{x}10^{-7}\text{AVP} - .0\text{x}10^{08}\text{TP}$	
	CLAY = TP	.18**
	= TP*HION	.23
	= TP*HION*AVP	.23
	= TP*HION*AVP*TC	.23
	CLAY = 21.612 + .0367TC + .0141TP − .004AVP + 1704173.69HION	
	TP = AVP	.49**
	= AVP*TC	.70**
	= AVP*TC*HION	.79**
	= AVP*TC*HION*CLAY	.80**
	TC = 156.275 + 4.506CLAY + 114.730TC + 8.347AVP − 94455318.567HION	

Table 17. (Continued)

Group	Model equations	R^2
OMT (34 samples)	TC = TP	.35**
	= TP*HION	.48**
	= TP*HION*CLAY	.55**
	= TP*HION*CLAY*AVP	.58**
	TC = 1.396 − .055CLAY + .005TP − .014AVP + 220982.09HION	
	AVP = TP	.64**
	= TP*HION	.75**
	= TP*HION*CLAY	.79**
	= TP*HION*CLAY*TC	.80**
	AVP = 23.800 − 1.101CLAY − 5.084TC + .105TP − 10026041.49HION	
	HION = AVP	.33**
	= AVP*TC	.45**
	= AVP*TC*CLAY	.47**
	= AVP*TC*CLAY*TP	.47**
	HION = $1.5\text{x}10^{-6} - 2.0\text{x}10^{-8}$CLAY + $2.1\text{x}10^{-7}$TC + $3.0\text{x}10^{-8}$AVP + $.0\text{x}10^{-8}$TP	
	CLAY = TC	.11++
	= TC*TP	.14++
	= TC*TP*AVP	.29*
	= TC*TP*AVP*HION	.32*
	CLAY = 30.84 − 3.341TC + .026TP − .185AVP − 1564827.67HION	
	TP = AVP	.64**
	= AVP*TC	.76**
	= AVP*TC*CLAY	.81**
	= AVP*TC*CLAY*HION	.81**
	TP = −60.55 + 8.14CLAY + 87.79TC + 5.60AVP + 16341746.10HION	

Table 17. (Continued)

Group	Model equations	R^2
NE (18 samples)	TC = CLAY	.07
	= CLAY*TP	.12
	= CLAY*TP*AVP	.16
	= CLAY*TP*AVP*HION	.17
	TC = −.468 + .035CLAY + .002TP − .005AVP − 54805.86HION	
	AVP = TP	.28*
	= TP*TC	.34*
	= TP*TC*HION	.37++
	= TP*TC*HION*CLAY	.37
	AVP = 10.920 − .676CLAY − 8.371TC + .092TP + 3161702.22HION	
	HION = CLAY	.34**
	= CLAY*TP	.45**
	= CLAY*TP*AVP	.47**
	= CLAY*TP*AVP*TC	.48**
	HION = $4.0x10^{-6} - 1.5x10^{-7}CLAY - 2.2x10^{-7}TC + 1.0x10^{-8}AVP + .0x10^{-8}TP$	
	CLAY = HION	.34**
	= HION*TC	.36*
	= HION*TC*AVP	.38++
	= HION*TC*AVP*TP	.38
	CLAY = 34.48 + 1.174TC − .002TP − .013AVP − 1248617.45HION	
	TP = AVP	.28*
	= AVP*HION	.38*
	= AVP*HION*TC	.43*
	= AVP*HION*TC*CLAY	.44++
	TP = 505.13 − 2.108CLAY + 58.982TC + 1.867AVP +31449475.20HION	

Table 17. (Continued)

Group	Model equations	R^2
FDS (19 samples)	TC = TP	.83**
	= TP*AVP	.85**
	= TP*AVP*HION	.89**
	= TP*AVP*HION*CLAY	.89**
	TC = −.317 + .008CLAY + .004TP − .027AVP + 233962.77HION	
	AVP = TC	.26*
	= TC*HION	.72**
	= TC*HION*CLAY	.75**
	= TC*HION*CLAY*TP	.75**
	AVP = 24.22 + .784CLAY − 12.82TC + .005TP + 8265114.42HION	
	HION = AVP	.21**
	= AVP*TC	.67**
	= AVP*TC*CLAY	.73**
	= AVP*TC*CLAY*TP	.73**
	HION = $-1.1\text{x}10^{-6} - 1.1\text{x}10^{-7}$CLAY + $1.1\text{x}10^{-6}$TC + $8.0\text{x}10^{-8}$AVP + $.0\text{x}10^{-8}$TP	
	CLAY = TP	.19++
	= TP*HION	.29++
	= TP*HION*AVP	.35++
	= TP*HION*AVP*TC	.36
	CLAY = 17.44 + .532TC + .015TP + .106AVP − 1598810.68HION	
	TP = TC	.83**
	= TC*CLAY	.85**
	= TC*CLAY*HION	.85**
	= TC*CLAY*HION*AVP	.85**
	TP = 175.80 + 7.52CLAY + 129.72TC + 0.311AVP + 6216974.65HION	

were calculated for models in which clay was the dependent variable. In general, models involving TP or AVP either as a dependent or independent variable increased the R^2 value as compared to the other dependent or independent variables in the model. Also, in all models, except the model with clay as the dependent variable, a three-independent variable model explained the variation as well as the four-variable model. This indicates that the fourth variable did not account for much of the variation.

MISSO, TM, FDS, OMT, and NE groups combined models also showed a similar trend involving TP and AVP. More of the variation may be explained by adding these two soil variables into the model equation. Low R^2 values were obtained for models having clay as the dependent variable. This may indicate that the other variables are not a good predictor of clay content in soils derived from alluvial sediments. The addition of the fourth independent variable to each model increased the R^2 very little.

In the individual groups, the high R^2 values were computed in the FDS group except when clay was the dependent variable (Table 17). Therefore, more variation among the variables was explained by the models in the FDS group than by the models in the other groups.

Model development involving chemical, physical, mineralogical, and landscape variables

Model equations were developed involving several chemical, physical, mineralogical, and landscape variables. The variables used in the model equations are listed in Table 18. The values for these variables are presented in Appendix E. Simple correlation coefficients between chemical, physical, mineralogical, and landscape variables are listed in Table 19.

Correlation coefficients are low for the majority of the relationships. High r values (> $\pm$.80) were computed between the variables MONTMOR and ILLITE (.96), LAT and TEMP (-.90), WIDFLP and STTOSI (.83), and VEG and TVEG (-.80). The r value for LONG and PPT was -.79.

The relationship between LONG and PPT would be expected because rainfall increases from the west to the east (longitude) in the midwestern states. For Iowa, this trend is illustrated in Figure 2. Wells (1963) reported an increase in micaceous clay minerals versus a decrease in rainfall (PPT). This is also true for the Colo soils studied. He also stated that the TK content decreased as rainfall increased. The r value for PPT and WGTTK in this study was .67. A reason for this different relationship is that Wells studied the TK content in the B horizons of major upland soils while WGTTK is the weighted average for the entire profile. Also, the soils in Wells' study were loess-derived while the sediments for some of the Colo soils, especially those from Illinois, came mostly

Table 18. List of chemical, physical, mineralogical, and landscape variables

X_i	Symbol	Variable identification
1	WGTCLAY	Weighted average clay content (%)
2	WGTTC	Weighted average total carbon (%)
3	WGTAVP	Weighted average AVP (ppm)
4	WGTTP	Weighted average TP (ppm)
5	WGTHION	Weighted average HION (moles/liter)
6	INTERST	Interstratified clay minerals (counts)
7	MONTMOR	Montmorillonite clay mineral (counts)
8	K-CL	Kaolinite chlorite clay minerals (counts)
9	ILLITE	Illite clay minerals (counts)
10	VEG	Distance to type of vegetation (meters)
11	TVEG	Type of vegetation[a]
12	SL-ER	Slope and erosion class[a]
13	PM	Parent material[a]
14	LONG	Longitude (degrees and minutes)
15	LAT	Latitude (degrees and minutes)
16	PPT	Precipitation (cm)
17	TEMP	Temperature (^{o}C)
18	WGTTK	Weighted average of TK (%)
19	WIDFLP	Width of the floodplain (meters)
20	BUPLSI	Distance from beginning uplands to site (meters)
21	STTOSI	Distance from the stream to site (meters)

[a]A more detailed explanation given in Appendix D.

Table 19. Simple correlation coefficients between chemical, physical, mineralogical, and landscape variables (No. = number of samples)

Between variables		r	No.	Between variables		r	No.
WGTCLAY and	WTTTC	.16	47	WGTAVP and	WGTTP	.49	47
	WGTAVP	.16	47		WGTHION	.38	47
	WGTTP	.18	47		INTERST	-.04	11
	WGTHION	.13	47		MONTMOR	.13	11
	INTERST	-.38	11		K-CL	-.08	11
	MONTMOR	.23	11		ILLITE	.17	11
	K-CL	.18	11		VEG	.33	46
	ILLITE	.17	11		TVEG	-.27	46
	VEG	.10	46		SL-ER	-.02	46
	TVEG	-.10	46		PM	-.16	46
	SL-ER	.01	46		LONG	.36	47
	PM	-.001	46		LAT	-.15	47
	LONG	.33	47		PPT	-.14	47
	LAT	.20	47		TEMP	.21	47
	PPT	-.31	47		WGTTK	-.08	16
	TEMP	-.12	47		WIDFLP	.20	46
	WGTTK	-.31	16		BUPLSI	.11	46
	WIDFLP	.08	46		STTOSI	.08	46
	BUPSLI	.21	46				
	STTOSI	.04	46	WGTTP and	WGTHION	.02	47
					INTERST	.10	11
WGTTC and	WGTAVP	-.22	47		MONTMOR	.37	11
	WGTTP	.42	47		K-CL	.34	11
	WGTHION	-.22	47		ILLITE	.46	11
	INTERST	.40	11		VEG	.07	46
	MONTMOR	.10	11		TVEG	-.14	46
	K-CL	.57	11		SL-ER	-.05	46
	ILLITE	.25	11		PM	.08	46
	VEG	-.14	46		LONG	-.03	47
	TVEG	-.10	46		LAT	.31	47
	SL-ER	.01	46		PPT	-.13	47
	PM	.03	46		TEMP	-.21	47
	LONG	-.14	47		WGTTK	-.33	16
	LAT	.50	47		WIDFLP	-.18	46
	PPT	-.12	47		BUPLSI	.06	46
	TEMP	-.51	47		STTOSI	-.26	46
	WGTTK	-.37	16				
	WIDFLP	-.34	46				
	BUPLSI	-.04	46				
	STTOSI	.28	46				

Table 19. (Continued)

Between variables		r	No.	Between variables		r	No.
WGTHION and	INTERST	-.41	11	K-CL and	ILLITE	.76	11
	MONTMOR	.58	11		VEG	.14	11
	K-CL	.16	11		TVEG	-.15	11
	ILLITE	.53	11		SL-ER	-.16	11
	VEG	.23	46		PM	.27	11
	TVEG	-.20	46		LONG	.35	11
	SL-ER	.08	46		LAT	.46	11
	PM	-.10	46		PPT	-.39	11
	LONG	.32	47		TEMP	-.39	11
	LAT	-.27	47		WGTTK	-.62	7
	PPT	-.03	47		WIDFLP	-.35	11
	TEMP	.26	47		BUPLSI	.22	11
	WGTTK	-.27	16		STTOSI	-.39	11
	WIDFLP	.23	46				
	BUPLSI	.07	46	ILLITE and	VEG	.32	11
	STTOSI	.10	46		TVEG	-.42	11
					SL-ER	-.01	11
INTERST and	MONTMOR	-.46	11		PM	.06	11
	K-CL	.09	11		LONG	.42	11
	ILLITE	-.23	11		LAT	.18	11
	VEG	-.39	11		PPT	-.33	11
	TVEG	.54	11		TEMP	-.06	11
	SL-ER	.07	11		WGTTK	-.57	7
	PM	.46	11		WIDFLP	-.35	11
	LONG	-.03	11		BUPLSI	-.12	11
	LAT	.31	11		STTOSI	-.34	11
	PPT	-.13	11				
	TEMP	-.21	11	VEG and	TVEG	-.80	46
	WGTTK	-.33	7		SL-ER	-.50	46
	WIDFLP	-.18	11		PM	-.11	46
	BUPLSI	.06	11		LONG	.56	46
	STTOSI	-.26	11		LAT	.08	46
					PPT	-.51	46
MONTMOR and	K-Cl	.67	11		TEMP	.02	46
	ILLITE	.96	11		WGTTK	.15	15
	VEG	.35	11		WIDFLP	.02	45
	TVEG	-.45	11		BUPLSI	-.06	45
	SL-ER	-.05	11		STTOSI	-.10	45
	PM	-.006	11				
	LONG	.38	11	TVEG and	SL-ER	.47	46
	LAT	.07	11		PM	.15	47
	PPT	-.32	11		LONG	-.43	47
	TEMP	.04	11		LAT	-.07	47
	WGTTK	-.58	7		PPT	.38	47
	WIDFLP	-.33	11		TEMP	-.04	47
	BUPLSI	-.19	11		WGTTK	-.21	16
	STTOSI	-.39	11				

Table 19. (Continued)

Between variables		r	No.	Between variables		r	No.
TVEG and	WIDFLP	.13	46	LAT and	PPT	-.62	47
	BUPLSI	.26	46		TEMP	-.90	47
	STTOSI	-.20	46		WGTTK	-.50	16
					WIDFLP	-.33	46
SL-ER and	PM	-.12	46		BUPLSI	-.14	46
	LONG	-.05	46		STTOSI	-.36	46
	LAT	-.27	46				
	PPT	.24	46	PPT and	TEMP	.52	47
	TEMP	.23	46		WGTTK	.67	16
	WGTTK	-.21	16		WIDFLP	-.05	46
	WIDFLP	.13	46		BUPLSI	.01	46
	BUPLSI	.26	46		STTOSI	.10	46
	STTOSI	.20	46				
				TEMP and	WGTTK	.48	16
PM and	LONG	-.03	47		WIDFLP	.33	46
	LAT	-.11	47		BUPLSI	.06	46
	PPT	.12	47		STTOSI	.42	46
	TEMP	.15	47				
	WGTTK	-.49	16	WGTTK and	WIDFLP	-.07	16
	WIDFLP	.25	46		BUPLSI	-.30	16
	BUPLSI	.49	46		STTOSI	.13	16
	STTOSI	.09	46				
LONG and	LAT	.20	47	WIDFLP and	BUPLSI	.42	46
	PPT	-.79	47		STTOSI	.83	46
	TEMP	-.16	47				
	WGTTK	-.50	16	BUPLSI and STTOSI		.12	46
	WIDFLP	.35	46				
	BUPLSI	.15	46				
	STTOSI	.16	46				

from glacial till-derived soils. The glacial till-derived soils in Illinois are generally high in micaceous clay minerals.

MONTMOR is related to ILLITE as indicated by the high r value for MONTMOR and ILLITE (.96). This is in contrast to Wells' (1963) interpretation that as micaceous clay minerals peak height (10 Å) decreased montmorillonite peak height (17 Å) increased.

As the floodplain increased in width, the distance from the site to the stream also increased. Also, the clay content should increase as distance increases from the stream. The principle involved is that the larger particles (sand, coarse silt) are deposited closer to the stream and finer particles (fine silt, clay) are deposited at greater distances from the stream. The r value indicates little relationship between the amount of clay in the soil (WGTCLAY) and the distance from the site to the stream (STTOSI) (Table 19).

The high correlation between VEG and TVEG is because a variable of zero was encoded if the distance to a transitional or forested upland soil was greater than 5000 meters. A number of sites had a distance greater than 5000 meters to the nearest transitional or forested upland soil.

Models similar to those developed from chemical and physical data for each sample in the entire soil were also developed from the weighted averages of selected chemical and physical variables in the soil. These models are presented in Table 20.

Table 20. Multiple regression equations and R^2 values of selected physical and chemical properties on all profiles using weighted averages

Multiple regression equations		R^2
WGTTC[a]	= WGTTP[b]	.18**
	= WGTTP*WGTAVP	.42**
	= WGTTP*WGTAVP*WGTCLAY	.44**
	= WGTTP*WGTAVP*WGTCLAY*WGTHION	.44**
	WGTTC = .319 + .016WGTCLAY + .002 WGTTP - .018WGTAVP - 35489.139WGTHION	
WGTAVP[a]	= WGTTP	.24**
	= WGTTP*WGTTC	.46**
	= WGTTP*WGTTC*WGTHION	.53**
	= WGTTP*WGTTC*WGTHION*WGTCLAY	.53**
	WGTAVP = -4.952 + .275WGTCLAY - 14.079WGTTC + .073WGTTP + 620344.175WGTHION	
WGTHION[a]	= WGTAVP	.14**
	= WGTAVP*WGTTP	.18**
	= WGTAVP*WGTTP*WGTCLAY	.18**
	= WGTAVP*WGTTP*WGTCLAY*WGTTC	.19**
	WGTHION = 3.0×10^{-7} + 1.0×10^{-8}WGTCLAY - 8.0×10^{-8}WGTTC + 2.0×10^{-8}WGTAVP - $.0\times10^{-8}$WGTTP	
WGTCLAY[a]	= WGTTP	.03
	= WGTTP*WGTHION	.04
	= WGTTP*WGTHION*WGTTC	.05
	= WGTTP*WGTHION*WGTTC*WGTAVP	.06
	WGTCLAY = 28.508 + 1.566WGTTC + .0004WGTTP + .036WGTAVP + 644308.642WGTHION	
WGTTP[a]	= WGTAVP	.24**
	= WGTAVP*WGTTC	.53**
	= WGTAVP*WGTTC*WGTHION	.54**
	= WGTAVP*WGTTC*WGTHION*WGTCLAY	.54**
	WGTTP = 147.573 + .227WGTCLAY + 151.342WGTTC + 5.933WGTAVP - 24519781.604WGTHION	

[a]46 samples, MINN2 deleted.

[b]Variables are added to the equation.

Trends, as described in the model equations of selected physical and chemical properties (Table 20), are also evident when using weighted average information. WGTTP and WGTAVP increase the R^2 in the models in which they are independent variables. The highest R^2 value was attained by the model: WGTTP = WGTAVP*WGTTC*WGTHION*WGTCLAY (.54). In this model for All Profiles using the data from each sample, the R^2 value was .53. Low R^2 values were calculated in which clay was the dependent variable.

Models using landscape variables as parameters were also selected to determine if a relationship existed among these parameters and selected chemical, physical, and mineralogical variables. These models were divided into the following groups:

MODEL A, effect of VEG, TVEG, SL-ER and PM as independent variables on different dependent variables

MODEL B, effect of VEG, BUPLSI, STTOSI, and WIDFLP as independent variables on different dependent variables

MODEL C, effect of PPT, WGTCLAY, and TEMP as independent variables on different dependent variables

MODEL D, effect of WGTTP, TEMP, ILLITE, and PPT as independent variables on different dependent variables

MODEL E-1, effect of WGTAVP, LAT, LONG, and WGTCLAY as independent variables on WGTTP

MODEL E-2, effect of LONG, WGTCLAY, LAT, and WGTTK as independent variables on ILLITE

MODEL F, effect of WGTCLAY, WGTTC, WSTAVK, and ILLITE as independent variables on different dependent variables

The multiple regression equations and R^2 values are listed in Table 21.

MODEL A had very low ($\leq \pm.20$) R^2 values for the models involving WGTTC, WGTTP, WGTCLAY, WGTHION, and WGTAVP as dependent variables. Some of the models were significant at the 1%, 5%, and 10% levels. The dependent variables were chosen because other researchers have shown a relationship between these variables. For example, the relationship between the TP content in the soil and the influence of vegetation on that amount has been investigated. TVEG as an independent variable added little to the model in which WGTTP was the dependent variable. A reason for this may be the way in which TVEG was indexed. The TVEG was determined by noting the type of vegetation which influenced the genesis of upland soils within 5000 meters of the site.

The relationship between WGTAVP and VEG was significant at the 5% level and had a R^2 value of .11. This indicated that, as the distance from the site to a transitional or forested soil in the uplands increased, the amount of WGTAVP for the entire profile increased. There may be even more of a relationship between WGTAVP and VEG if the 25 to 100 cm AVP zone was used instead of the entire profile. The variable TVEG adds little to the final model: WGTAVP = VEG*SL-ER*PM*TVEG (R^2 = .15).

Table 21. Multiple regression equations and R^2 values for different models

Multiple regression equations		R^2
	MODEL A[a]	
WGTTC	= VEG	.02
	= VEG*TVEG	.09
	= VEG*TVEG*SL-ER	.09
	= VEG*TVEG*SL-ER*PM	.09
	WGTTC = 2.00 - .0001VEG - .311 TVEG + .003SL-ER + .0003PM	
WGTTP	= TVEG	.01
	= TVEG*PM	.03
	= TVEG*PM*VEG	.03
	= TVEG*PM*VEG*SL-ER	.03
	WGTTP = 521.30 - .004VEG - 36.785TVEG + .346SL-ER - .177 PM	
WGTCLAY	= VEG	.01
	= VEG*SL-ER	.02
	= VEG*SL-ER*TVEG	.02
	= VEG*SL-ER*TVEG*PM	.02
	WGTCLAY = 30.07 + .0003VEG + .444TVEG + .031SL-ER + .0008PM	
WGTHION	= VEG	.05**
	= VEG*SL-ER	.10**
	= VEG*SL-ER*PM	.11**
	= VEG*SL-ER*PM*TVEG	.11**
	WGTHION = $-1.5\text{x}10^{-7}$ - $.0\text{x}10^{-8}$VEG - $3.0\text{x}10^{-8}$TVEG + $2.0\text{x}10^{-8}$SL-ER - $.0\text{x}10^{-8}$PM	
WGTAVP	= VEG	.11*
	= VEG*SL-ER	.14*
	= VEG*SL-ER*PM	.14++
	= VEG*SL-ER*PM*TVEG	.15
	WGTAVP = 8.220 + .003VEG + .842TVEG + .262SL-ER - .018PM	

[a]46 samples, MINN2 deleted.

Table 21. (Continued)

Multiple regression equations		R^2
	MODEL B[a]	
WGTTP	= STTOSI	.07++
	= STTOSI*BUPLSI	.08
	= STTOSI*BUPLSI*VEG	.08
	= STTOSI*BUPLSI*VEG*WIDFLP	.08
	WGTTP = 531.490 + .002WIDFLP + .041BUPLSI − .126STTOSI + .003VEG	
WGTCLAY	= BUPLSI	.02
	= BUPLSI*VEG	.03
	= BUPLSI*VEG*WIDFLP	.03
	= BUPLSI*VEG*WIDFLP*STTOSI	.03
	WGTCLAY = 33.485 − .0006WIDFLP − .001BUPLSI + .0007STTOSI − .0001VEG	
	MODEL C[b]	
ILLITE	= PPT	.11
	= PPT*WGTCLAY	.21
	= PPT*WGTCLAY*TEMP	.21
	ILLITE = 154.1 − 9.437PPT + 2.339TEMP + 32.074WGTCLAY	
INTERST	= WGTCLAY	.16
	= WGTCLAY*PPT	.26
	= WGTCLAY*PPT*TEMP	.41
	INTERST = 1042.036 + 47.965PPT − 276.882TEMP − 43.253WGTCLAY	
MONTMOR	= PPT	.10
	= PPT*WGTCLAY	.24
	= PPT*WGTCLAY*TEMP	.26
	MONTMOR = 98.823 − 49.718PPT + 119.408TEMP + 120.359WGTCLAY	
K-CL	= PPT	.15
	= PPT*WGTCLAY	.39
	= PPT*WGTCLAY*TEMP	.40
	K-CL = −119.953 − .353PPT − 50.093TEMP + 28.1WGTCLAY	

[b]11 samples.

Table 21. (Continued)

Multiple regression equations		R^2
	MODEL D[b]	
WGTTC	= WGTTP	.39*
	= WGTTP*TEMP	.47++
	= WGTTP*TEMP*ILLITE	.50
	= WGTTP*TEMP*ILLITE*PPT	.51
	WGTTC = .554 + .005PPT − .080TEMP + .0003ILLITE + .002WGTTP	
WGTCLAY	= TEMP	.34++
	= TEMP*ILLITE	.42
	= TEMP*ILLITE*PPT	.45
	= TEMP*ILLITE*PPT*WGTTP	.45
	WGTCLAY = 24.2 − .044PPT + 1.082TEMP + .002ILLITE − .001WGTTP	
	MODEL E-1[c]	
WGTTP	= WGTAVP	.24**
	= WGTAVP*LAT	.26**
	= WGTAVP*LAT*LONG	.28**
	= WGTAVP*LAT*LONG*WGTCLAY	.28**
	WGTTP = 289.318 + 19.171LAT − 8.071LONG + 2.601WGTCLAY + 4.622WGTAVP	
	MODEL E-2[d]	
ILLITE	= LONG	.13
	= LONG*WGTCLAY	.14
	= LONG*WGTCLAY*WGTTK	.15
	= LONG*WGTCLAY*WGTTK*LAT	.15
	ILLITE = −2396.793 + 30.632LONG + 3.703LAT + 54.964WGTTK − 8.658WGTCLAY	

[c]47 samples.

[d]7 samples.

Table 21. (Continued)

Multiple regression equations		R^2
	MODEL F[e]	
LAT	= WGTTC	.72**
	= WGTTC*WGTCLAY	.76*
	= WGTTC*WGTCLAY*WSTAVK	.82++
	= WGTTC*WGTCLAY*WSTAVK*ILLITE	.84
	LAT = 43.590 + 6.457WGTTC + .0007ILLITE − .307WGTCLAY − .059WSTAVK	
LONG	= ILLITE	.19
	= ILLITE*WGTCLAY	.35
	= ILLITE*WGTCLAY*WSTAVK	.43
	= ILLITE*WGTCLAY*WSTAVK*WGTTC	.43
	LONG = 60.046 − .535WGTTC + .004ILLITE + .893WGTCLAY + .080WSTAVK	

[e]8 samples.

MODEL B shows little relationship between the dependent variables WGTTP and WGTCLAY and the independent variables VEG, BUPLSI, STTOSI, or WIDFLP. The simple regression equation WGTTP = STTOSI is significant at the 10% level. Therefore, the WGTTP and WGTCLAY contents are not significantly affected by these independent variables.

K-CL, MONTMOR, and ILLITE as well as INTERST were indexed to determine if these clay minerals are affected by PPT, TEMP, or WGTCLAY. The model equations INTERST = WGTCLAY*PPT*TEMP and K-CL = PPT*WGTCLAY*TEMP had moderately high R^2 values, .41 and .40, respectively.

In MODEL D, moderately high R^2 values were computed for the model equations WGTTC = WGTTP*TEMP*ILLITE*PPT and WGTCLAY = TEMP*ILLITE*PPT*WGTTP. In both equations, the last independent variable added little to the R^2.

The equation in MODEL E-1 shows, at the 1% level of significance, a correlation between WGTTP and WGTAVP and the other independent variables when they are added stepwise to the model. Adding the independent variables LAT and LONG increased the R^2 value to .28. MODEL E-2 (Table 21) indicates a level of significance between and among the variables that is greater than 10%.

As discussed in the section on total carbon distribution, the Colo soils sampled in Missouri have less WGTTC than the Colo soils sampled in Minnesota. This is implied by the simple regression equation LAT = WGTTC (R^2 = .72). There should also be a correlation between WGTTC and TEMP because as TEMP increases the rate of decomposition of organic matter should also increase (Van't Hoff's Law). The r value for this relationship is -.51 (Table 19). This is significant at the 1% level for 47 samples. This suggests that as the TEMP decreases from Missouri to Minnesota, the WGTTC increases. The other independent variables, when added to the F model, increased the R^2 value to .84, the highest among all model equations involving chemical, physical, mineralogical, and landscape variables. The high R^2 value for the model equation LAT = WGTTC*WGTCLAY*WSTAVK*ILLITE implies a trend of these variables in a north-south direction.

LONG was used as a dependent variable with ILLITE, WGTCLAY, WSTAVK and WGTTC as independent variables. The simple and multiple regression models using these variables were not significant at the 1%, 5%, or 10% level.

Clay Mineralogy

The clay mineralogy of selected horizons from the Colo soils included in this study was determined. Computer printouts of counts versus degrees two theta for the clay mineralogy samples determined on the Picker x-ray diffractometer are presented in Appendix C. The samples which were x-rayed on the General Electric diffractometer were indexed as to the presence or absence of MONTMOR, K-CL, and ILLITE clay minerals. The results are presented in Table 22.

INTERST or mixed layer clay minerals are the dominant minerals in the majority of the Colo soils in this study based on relative peak heights. MONTMOR, K-CL, and ILLITE are minor clay minerals as interpreted by relative peak heights. For most of the soils, the MONTMOR clay mineral peak was masked by the peak for INTERST. The peaks for INTERST were mostly broad and poorly defined as shown in soil 31-2 (Figure 54). Well-defined peaks, at approximately 14 Å, are presented in soils N2 and MINN2. K-Cl and ILLITE peaks were more definitive in more Colo soils than the INTERST or MONTMOR. This is especially true for the x-ray

Table 22. X-ray diffraction clay mineral peaks

	Untreated		10% $MgCl_2$ ethylene glycol	
Soil sample	Degrees two theta	d-spacing (Å)	Degrees two theta	d-spacing (Å)
21-1	6.05 8.75 12.4	14.6 10.1 7.1	-	-
21-3	6.1 8.75 12.45	14.5 10.0	-	-
21-10A	6.1 8.7 12.4	14.5 10.2 7.1	-	-
31-6A[a]	6.05 8.76 12.3	14.6 10.1 7.1	4.85 8.75 12.3	18.2 10.1 7.1
31-7A[a]	6.1 8.8 12.35	14.5 10.0 6.6	5.1 8.9 12.4	17.3 9.9 7.1
63-1A	6.05 8.8 12.4	14.6 10.0 7.1	4.8 8.8 12.4	18.4 10.0 7.1
63-5	6.1 8.8 12.4	14.5 10.0 7.1	5.1 8.8 12.35	17.3 10.0 7.1
71-1	6.0 8.75 12.35	14.7 10.1 7.1	-	-
71-5	6.2 8.6 12.35	14.2 10.3 7.1	-	-
71-12	6.25 8.7 12.4	14.1 10.2 7.1	-	-
95-1A	6.1 8.8 12.3	14.5 10.3 7.2	-	-

[a]Soil 31-2.

Table 22. (Continued)

Soil sample	Untreated: Degrees two theta	Untreated: d-spacing (Å)	10% MgCl2 ethylene glycol: Degrees two theta	10% MgCl2 ethylene glycol: d-spacing (Å)
95-2A	6.15	14.3	-	-
	12.4	7.1		
95-3A	6.1	14.5	-	-
	8.75	10.1		
	12.4	7.1		
N2-1	-	-	6.1	14.5
			8.8	10.0
			12.4	7.1
N2-4A	6.1	14.5	5.4	16.4
	8.7	10.2	9.1	9.65
	12.35	7.1	12.6	7.00
N2-7	6.05	14.6	-	-
	8.75	10.1		
	12.3	7.1		

patterns for heat treated samples. The clay mineralogy within the Colo soils changed slightly with depth.

Interpretations of the clay mineralogy were based on changes in d-spacing after various sample treatments. Two sample treatments considered by Carroll (1970) to be principal auxiliary treatments for the identification of clay minerals are glycolating the sample with 10% $MgCl_2$ ethylene glycol (MGCLEG) and heating the sample to 300°C (HEATED). Both treatments cause distinctive expansion or contraction of the space lattice.

As mentioned earlier, INTERST clay minerals seems to predominate in these soils. Commonly, INTERST occurs (1) by regular interstratification of layers, (2) by random interstratification of layers, and (3) by zonal segregation of layers where sufficient numbers of each kind occur together so that x-ray analysis reveals them to be separate phases (Sawhney, 1977). The kind of interstratification in the Colo soils is not known. It is assumed that the clay minerals that are interstratified in most of the Colo soils are expandable 2:1 types. This assumption was made after examining the x-ray patterns and determining that the 14 Å untreated peak expanded to 18 Å when glycolated and contracted to approximately 10 Å when heated to 300°C. The intensity of the 10 Å peak may also be due to the presence of illite.

The effects of PPT and TEMP may be shown by comparing the clay mineralogy in Colo soils from northwestern Iowa (Lyon County, soil 60) and southeastern Iowa (Lee County, soil 56). The PPT and TEMP for these two counties are 64 cm and 8.0°C in Lyon County and 89 cm and 11.0°C in Lee County.

Inspection of the plots for Colo soils 56 and 60 indicates more well-defined clay mineral peaks are present with increasing soil depth. This is especially apparent in the x-ray patterns for MGCLEG and HEATED for the C horizon in soil 56. The C horizon in soil 60 had broader, less well-defined clay mineral peaks. The type of clay minerals were similar, especially INTERST, ILLITE, and K-CL.

MONTMOR (r = -.32), K-CL (-.39), and ILLITE (-.33) were moderately well-correlated with PPT. INTERST (-.13) was not well-related. K-Cl (r = -.39) and INTERST (-.21) were moderately well-correlated with TEMP. These r values were calculated with 11 samples.

To test the hypothesis that the type of vegetation may have an effect on the clay mineralogy in Colo soils, soil 31-2 was chosen to represent Colo soils formed in a transitional area of the state. Soil 95 was chosen as a representative Colo soil in a prairie area of the state.

Poorly defined clay mineral peaks, except for K-Cl (Figure 54) are shown in the surface layer in soil 31-2. In the 51-56 cm zone, (Figure 55) the peaks become well-defined and sharper. The MGCLEG peaks indicate a d-spacing of 15.4 Å, 10.1 Å, and 7.1 Å. With increasing depth, the 10.1 Å and 7.1 Å peaks (MGCLEG) remain well-defined. The 15.4 Å peak is missing in the 91-97 cm (Figure 56) and 107-112 cm (Figure 57) zones. An approximately 18 Å peak appears on the x-ray pattern for MGCLEG sample (Table 22)(91-97 cm).

Similar trends are expressed in soil 95. It should be noted that these trends are comparatively similar, even though the parent materials of the associated upland soils are different. Plotted in Figure 72 is the x-ray diffraction pattern for the surface layer in soil 95. The MGCLEG sample does not show any peaks. The HEATED pattern shows sharp peaks at

9.9 and 7.1 Å. As in soil 31-2 and others, the peaks become more distinct with increasing soil depth (Figures 72, 73, 74, 75, and 76).

The Colo soil sampled in Champaign County, Illinois had low peak heights of ILLITE as compared to WGTTK. The loess-derived upland soils in the area which this soil was obtained had a low percentage of illite, chlorite, and kaolinite relative to the percentage of expandable clay minerals (Wickham, 1979). Below the loess are parent materials which are considerably higher in illite percentage. In some, the illite content is greater than 80%. Therefore, the majority of the sediments may be originally from the modern loess-derived soil.

Highest WGTCLAY was presented in the MINN2 Colo soil. This soil had the best well-defined clay peaks for all samples in the profile (Figures 86, 87, 88, and 89). The peak heights at approximately 14.5 Å did not greatly expand when the samples were glycolated. A 10 Å and 7 Å peak existed in all samples but the peak intensities were less in the 127-140 cm zone.

The mineralogy of the soil is indicated in the soils classification. The Colo soils are classified at the family level as having mixed mineralogy. Mixed, as defined by Soil Taxonomy (Soil Survey Staff, 1975b), has <40% of any one mineral other than quartz or feldspars in the .02 to 2 mm particle-size. This mineralogy class and the clay mineralogy in the soil profile as determined in this study should not be confused. The mineralogy class at the family level of the soil classification system is determined within a specific control section on a specified size fraction.

The clay mineralogy for the Colo soils included in this study was determined for selected samples at varying depths. The <.002 mm size fraction was used. Therefore, if montmorillonite, kaolinite, or illite dominated the clay mineralogy in Colo soils, the mineralogy class at the family level would still be mixed according to the system used in Soil Taxonomy (Soil Survey Staff, 1975b).

Morphological Properties and Classification

One of the objectives of this study was to characterize the Colo soil series as mapped in the NCR. Another objective was to discuss the classification of the Colo soil series. One method by which soil scientists characterize soils is to describe its morphological properties. Soil scientists describe a soil profile by observing and recording the observable soil properties according to the nomenclature and procedures described in the Soil Survey Manual (Soil Survey Staff, 1951b) and Soil Taxonomy (Soil Survey Staff, 1975b). The value of soil descriptions depends upon the modality of the site, and the completeness and clarity of the descriptions (Soil Survey Staff, 1951b).

The basis for classifying soils is the soil profile description (Appendix A). Laboratory data add to our understanding of the soil profile descriptions.

Most of the Colo soils were sampled at the type location for the county soil survey or as near as possible to the site. The soil profile, therefore, should represent the modal Colo soil mapped in that county.

Morphological properties

Horizon sequence   A soil horizon is a layer that is approximately parallel to the soil surface. It has some set of properties that have been produced by soil-forming processes. It has some properties that are not like those of the layers above or beneath it (Soil Survey Staff, 1951b). Horizon designations and number and thickness of horizons, which are a part of the soil profile description, are somewhat arbitrary determinations made by soil scientists.

The horizon sequences, color of A horizon, thickness of A horizon, and several other morphological properties are listed in Table 23. The majority of the Colo soils described had an A-B-C horizon sequence. Others had an A-B-BC-C (soil 29), A-AC-C (soil 31-1), and A-C (soil 96-2) horizon designations.

The thickness of the A horizon (Table 23) ranged from 20 cm in soil M2 to greater than 152 cm in soil N2. Soil N2 had a thick A horizon because a B horizon was not described. The thickness of the B horizon ranged from a minimum of 20 cm

Table 23. Summary of morphological properties of all Colo profiles sampled in this study

Soil	Horizon sequence	Matrix color of A horizon (moist)	Thickness of: A horizon	Mollic epipedon	B horizon	Solum	Depth to mottles	Weighted ave. clay content 25-100 cm (%)
			(cm)					
Mo group								
60	A-C	10YR 2/1,3/1	99	145	-	99	-	32.4
Average			99	145		99		32.4
GPS group								
75	A-B-C	10YR 3/2, 3/1, 2/1	38	123	85	123	-	35.1[a]
71	A-B-C	10YR 2/1	38	102	74	112	-	34.3[a]
18	A-B-C	10YR 2/1, N 2/0, 10YR 3/1	76	132	56	132	-	36.1
21	A-B-C	N 2/0	53	109	56	109	-	33.8
81	A-B-C	10YR 2/1	51	152	101	101	-	34.8[a]
Average			51	124	74	115		34.8
MIH group								
97	A-AC-C	10YR 3/1, 2/1	131	152	-	140	-	35.5[a]
43	A-B-C	N 2/0	61	137	76	137	-	34.2[a]
Average			96	145	76	139		34.8
M group								
5	A-B-C	N 2/0, 10YR 2/1,3/1	84	157	28	112	-	33.9
36	A-B-C	N 2/0, 10YR 2/1	79	99	61	140	-	33.6[a]

24	A-B-C	10YR 2/1	53	147	82	135	-	37.1[a]
Average			72	134	57	129	-	34.9
<u>SSM group</u>								
1	A-B-C	10YR 2/2	61	117	76	137	-	36.2
88	A-B-C	10YR 2/1,3/1	107	137	20	137	-	38.0[a]
73	A-B-C	N 2/0	36	152	106	142	-	33.8[a]
Average			68	135	67	139	-	36.0
<u>ASE group</u>								
4	A-B-C	10YR 2/1	28	94	74	112	94	32.8
Average			28	94	74	112	94	32.8
<u>CKL group</u>								
63	A-B-C	10YR 2/1	33	94	81	114	114	31.4[a]
Average			33	94	81	114	114	31.4
<u>OMT group</u>								
62	A-B-C	10YR 2/1	79	152	57	136	94	27.7
44	A-B-C	N 2/0, 10YR 2/1	61	123	79	140	-	37.7
29	A-B-BC-C	N 2/0,10YR 2/1	61	123	57	118	123	27.9[a]
79	A-B-IIC	N 2/0,10YR 2/1	52	87	67	119	152	32.9[a]
48	A-B-C	N 2/0,10YR 2/1	30	123	93	123	-	34.7
54	A-B	10YR 2/1,N 2/0	66	104	86	152+	104	33.4
Average			58	119	73	131	118	32.0
<u>GH group</u>								
56	A-B-C	10YR 2/1,N 2/0	61	91	74	135	123	30.8
Average			61	91	74	135	123	30.8

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[a]Clay content not determined on all horizons between 25-100 cm. Weighted average for samples between 25-100 cm for those horizons analyzed.

Table 23. (Continued)

Soil	Horizon sequence	Matrix color of A horizon (moist)	Thickness of: A horizon	Mollic epipedon	B horizon	Solum	Depth to mottles	Weighted ave. clay content 25-100 cm (%)
			-----------------	-----------------	(cm)	-----------------	-----------------	
<u>TM group</u>								
86	A-B-C	N 2/0 10YR 2/1	84	114	46	130	130	33.1[a]
16	A-B-C	N 2/0 10YR 2/1	61	71	43	104	71	26.2
52	A-B-C	10YR 2/1	38	94	71	109	-	35.2
Average			61	93	53	114	-	31.5
<u>DT group</u>								
38	A-B-C	10YR 2/1	61	145	61	122	84	29.0
6	A-B-C	10YR 2/1 N 2/0	61	91	41	102	112	34.9
Average			61	118	51	112	98	32.0
<u>FDS group</u>								
31-1	A-AC-C	10YR 2/1, 10YR 3/1	111	124	-	111	99	29.4[a]
Average			111	124	-	111	99	29.4
<u>D group</u>								
22-1	A-B-C	10YR 2/1	43	130	87	130	130	35.3[a]
22-2	A-AC-C	N 2/0, 10YR 2/1, 10YR 3/1	106	127	-	106	-	31.1[a]
Average			75	129	-	118	-	33.2
<u>F group</u>								
96-1	A-AC-C	10YR 2/1	106	152	-	106	-	30.1[a]
96-2	A-C	N 2/0,10YR 2/1	130	152	-	130	-	39.6[a]

31-2	A-C	10YR 2/1,N 2/0	107	152	-	107	-	31.2
Average			119	152	-	119	-	35.4
<u>CNW group</u>								
95	A-C	N 2/0,10YR 2/1 10YR 3/1	119	152	-	119	-	33.4[a]
Average			119	152	-	119	-	33.4
<u>NE group</u>								
N1	A-B-C	10YR 3/2,N 2/0 10YR 2/1	79	109	30	109	-	34.8[a]
N2	A	10YR 2/1,3/1	152	152	-	152+	-	30.2
N3	A-B-C	10YR 2/1,N 2/0	94	140	46	140	94	37.5[a]
N4		10YR 3/1						
N4	A-B-C	10YR 2/1,3/1	25	89	87	112	112	33.4[a]
Average			88	123	54	128	103	34.0
<u>MISSO group</u>								
M1	A-B-C	10YR 2/1	43	127	64	107	69	27.9
M2	A-B	10YR 3/1,2/1	20	102	132+	152+	102	35.8
M3	A-B	10YR 2/1	33	122	119+	152+	-	33.1
M4	A-B	10YR 2/1	36	137	116	152+	36	34.8
Average			33	122	108	141	69	32.9
ILL group								
I	A-B	10YR 2/1	30	97	92+	122+	-	29.4
I2	A-B-C	10YR 3/1,2/1	97	127	30	127	23	27.2
Average			64	112	61	125	23	28.3
<u>MINN group</u>								
MINN 1	A-C	N 2/0,10YR 2/1	127	152+	-	127	140	48.7
MINN 2	A-C	10YR 2/1	91	91	-	91	-	25.7
Average			109	122	-	109	140	37.2

in soil 88 to a maximum of 119 cm in soil M3.

The presence or absence and thickness of the B horizon were determined largely from the structure and color of the soil. Soil structure refers to the aggregation of individual soil particles into larger units with planes of weakness between them (Buol et al., 1973). For most of the profiles, if the structure of the soil was subangular blocky, angular blocky or prismatic, a "structural" B horizon was described. In some of the Colo profiles, for instance in soil 1, the structural B horizons would quality as a cambic diagnostic subsurface horizon. A cambic horizon does not have the dark color, organic matter content, and structure that are definitive for a mollic or an umbric epipedon. Other properties needed for a cambic horizon are described in Soil Taxonomy (Soil Survey Staff, 1975b).

Some soil scientists question the designation of B horizons in soils derived from recent alluvial sediments. Usually, this horizon indicates an alteration of material from its original condition. Alluvial-derived soils are in an early stage of development, and therefore, should have little alteration of the original material. As indicated by some of the Colo soil properties, this assumption is not necessarily correct.

Solum thickness ranged from 91 cm in soil MINN2 to greater than 152 cm in soils 54, N2, M2, M3, and M4.

The solum is the set of genetic horizons (A and B) developed by soil-building forces (Soil Survey Staff, 1975b). Buol et al. (1973) considered the soil solum to be that part of the soil profile which is influenced by plant roots. The criterion used to determine solum thickness in this study was the structural development of the soil. A C horizon was described when the soil became massive.

The thickness of the soil solum may be used to indicate the degree of soil profile development (Collins, 1977; Kuehl, 1978). This criterion has also been used to show the influence of vegetation on the soil's genesis. Soil morphological properties in Table 23 have been averaged by groups to determine if a trend exists between the degree of soil profile development and the genesis of the soil. The solum thickness varied little among TM (114 cm), DT (112 cm), D (118 cm), FDS (111 cm), and F (119 cm) groups. Even though the upland soils in these groups formed under different vegetation, a trend based on solum thickness was not apparent among these Colo groups. Solum thickness increased from the MINN2 soil in Minnesota to the soils in the TM group of east-central Iowa to the soil in the GH group in southeastern Iowa. The MINN2 soil did not have a B horizon. The average thickness of the B horizon in the TM group was 53 cm while the soil in GH group had a B horizon that was 74 cm thick. Hence, solum thickness was greatly affected by the thickness of the B horizon in these soils. The B horizon was determined from the soil structure and is an indication of the degree of soil profile development.

<u>Soil color</u> Color is the most obvious and easily determined of soil characteristics (Soil Survey Staff, 1975b). Color when combined with soil structure, is a useful and important characteristic for soil identification. Much can be determined about a soil from its color, although color has little direct influence on the soil. Soil color has been used as a differentiating characteristic at high categoric levels in most systems of soil classification.

Matrix colors of the A horizon for the Colo soils are listed in Table 23. The majority of the A horizons were either N 2/0 or 10YR 2/1. Thickness of the mollic epipedon in the Colo soils is also listed in Table 23. The colors in the matrix in the Colo profile to a depth of 91 cm and the thickness of the mollic epipedon are important criteria used to define the Colo soil series. The importance of these two properties will be discussed in the section on the classification of the Colo soil series.

The color of the A horizon has been used as an indicator of the relative organic matter content in soils. In general, dark-colored soils in the midwestern United States are higher in organic matter than light-colored soils. Collins (1977) noted several morphological properties which are related to organic matter content and vegetational influence on upland soils.

Studying the relationship between the organic matter content and the effect of vegetation on that amount is difficult in this study. This is because the soil would not have been mapped as Colo if it did not have deep, dark colors. Therefore, even in forested areas of the state, the color of the A horizon is black or very dark gray. If a lighter colored layer is present on the surface, it may indicate recent sediment or overwash. The color of this material should not be considered when determining if the soil has a mollic epipedon greater than 91 cm.

Mottling The word "mottled" means marked with spots of color (Soil Survey Staff, 1975b). Some mottled colors are associated with poor drainage, as is the case in the Colo soils. The color and pattern of the mottles are described as to contrast, abundance, and size. Table 23 lists the depth to mottles in the Colo soils. Knowledge of mottling patterns and depth to mottles in the Colo soil is important. One criterion used to classify the Colo soil as an Aquoll is the presence of mottles at a specified location in the soil profile. A more detailed discussion of the importance of mottles in the Colo soils is in the classification section.

Classification The Colo series is a member of the fine-silty, mixed, mesic Cumulic Haplaquolls. The central concept of Cumulic Haplaquolls is a soil with an overthickened mollic epipedon and an irregular decrease of organic carbon with depth.

> They are permitted but not required to have a buried A1 horizon. They have received occasional fresh sediments at a rate such that the accumulation of organic carbon kept pace with sedimentation. They lie on floodplains, in depressions, and along small drainageways at the base of slopes. They are widely distributed, but are not extensive soils (Soil Survey Staff, 1975b).

The Colo series is a member of the Mollisol order and, therefore, must have horizons that meet all the requirements for a mollic epipedon. Briefly, a mollic epipedon is a diagnostic surface horizon. Its definition is based on its morphology rather than its genesis. The mollic epipedon is a thick, dark-colored, humus-rich surface horizon or horizons in which bivalent cations are dominant on the exchange complex. Formation of the mollic epipedon is thought to be from subsurface decomposition of organic matter in association with bivalent cations, especially calcium (Soil Survey Staff, 1975b). Two of the more important requirements for a mollic epipedon for this discussion are the moist and dry soil matrix colors and the organic carbon content. The other criteria are cited in Soil Taxonomy (Soil Survey Staff, 1975b). The Colo soils sampled for this study had a mollic epipedon and were classified as Mollisols.

The soils in the Colo series are classified as Aquolls. Aquolls are Mollisols that have an aquic moisture regime or are artifically drained, and that have "dominantly low chroma, commonly with olive hues, and have high-contrast mottles below a black epipedon" (Soil Survey Staff, 1975b). Other characteristics associated with wetness are stated in Soil Taxonomy

(Soil Survey Staff, 1975b). One criterion is that, if the soil lacks mottles, the chroma must be less than 1 in the lower part of the mollic epipedon. Mottles were not described in many of the Colo soils (Table 23). A number of these soils did not have chroma of less than 1. In some of the Colo soils which did not have mottles, iron and or manganese oxides or concretions were noted. Usually, the presence of iron or manganese oxides or concretions indicates some degree of wetness.

All the Colo soils described met the requirement for the great group, Haplaquoll. At the subgroup level in the classification scheme, the Colo soils are classified as Cumulic Haplaquolls. A Cumulic Haplaquoll was defined previously. A distinction between Cumulic Haplaquoll and Typic Haplaquoll is that a Cumulic Haplaquoll has a mollic epipedon greater than 60 cm thick. Another distinction is that Cumulic Haplaquolls have an irregular decrease of organic carbon and reaches a level of .3% carbon or less in some subhorizon within 1.25 meters of the soil surface.

All the Colo soils studied had a mollic epipedon greater than 60 cm (Table 23). The requirement that soils in this subgroup have an irregular decrease of organic carbon content with depth is not met in many of the Colo soils. This is a classification problem still to be resolved.

At the family level, the particle-size class is fine-silty. Fine-silty indicates that less than 15% of the particles are fine sand (diameter .25-.1 mm) or coarser and 18 through 34% of the particles are clay-size in the fine-earth fraction. The control section to determine the particle-size class is 25 to 100 cm. The weighted average clay content for each Colo soil in this zone is given in Table 23. A number of the Colo soils had greater than 35% clay content in the control section, and therefore, are outside the range for the fine-silty particle-size class. Sand contents were also greater than 15% in the control section in some soils but most of the sand had a diameter between .05 and .1 mm in size.

As discussed earlier, the mineralogy class for all Colo soils was mixed. Soil temperature was not measured but it was assumed to be mesic, especially in Iowa.

The series criteria are more refined than the criteria at the family level of the classification system. Table 24 summarizes some of the ranges in characteristics for the Colo soil series.

Other than the Colo soils which are outside the range for the weighted average clay contents in the control section, the following Colo soils are outside the range for the series. Soils 16, 52, and N4 have a mollic epipedon less than 91 cm thick. Soils 18, 21, 71, and N1 have pH values which exceed the allowable ranges. All other soils sampled met the requirements for a Colo soil.

Table 24. Summary of profile properties in the range in characteristics for the Colo soil series

Property	Description
Solum thickness	91 to 137 cm
Carbonates	Absent in solum commonly to depth depths of 152 cm
pH	0-30 cm neutral to medium acid >30 cm neutral or slightly acid
Mollic epipedon	>91 cm
Color of A horizon	10YR, 5Y or N hue; 2 or 3 value 0 or 1 chroma
Texture of A horizon	0-25 cm silty clay loam or heavy silt loam >25 cm averages between 27 and 35% clay
Clay content below A horizon	Averages between 32 and 35% clay Soils averaging 36 to 40% clay are not excluded if control section <35% clay
Mottles	>61 cm few to common high chroma mottles

SUMMARY

The results of this study provide a background concerning the genesis of soils derived from alluvial sediments. The project began with the general objective of studying the Colo soil series as mapped in the NCR. Forty-seven soil profiles from Iowa, Nebraska, Missouri, Illinois, and Minnesota collected from or near to the county type location were described and sampled to determine selected physical, chemical, mineralogical, and morphological properties. Selected landscape variables also were indexed and used as parameters in model equations.

The results of the physical, chemical, and mineralogical analyses were statistically studied in the following groups: (a) All Profiles, (b) by state (only out-of-state samples), (c) by soil association areas in Iowa, and (d) as individual soil profiles.

Statistical analyses included calculation of means, minimum values, maximum values, and weighted averages, as well as simple correlation coefficients. From these results, multiple linear regression equations were developed to determine if relationships existed between soil variables.

Particle-Size Distribution

1. The weighted average clay content of the Colo profiles was 30.4%.

2. Clay distributions show either of two patterns. One is almost a straight line. The second pattern is a curve that increases with depth to a maximum then decreases with depth.

3. Average B/A and/or subsurface/surface clay ratios ranged from .9 to 1.3.

4. No regional trends were noted in the clay contents or clay depth distributions.

5. Particle-size stratification was not evident in any of the profiles.

6. Generally, the sand-size fraction was very fine. Medium sand was actually iron and manganese concretions. The Colo profile collected from within the Clarion-Nicollet-Webster soil association area had the highest sand content.

7. Factors influencing the clay content in upland soils seem to have had little influence on the clay content of associated soils formed in alluvial sediments.

Available Phosphorus (AVP) Distribution

1. Most of the Colo profiles had an eluviated zone and illuviated zone of AVP which are similar to the zones which occur in upland soils, but in some Colo profiles, they were not as well-expressed.

2. The weighted averages in the control sections were low in some profiles because the AVP generally decreased with

depth to a minimum at about 40 cm.

3. The average AVP in the surface layer of the Colo soils groups were generally higher than the average AVP content in the surface layer of the principal upland soils. The Colo soils receive sediments from the upland soils and phosphorus is transported with the sediments.

Total Phosphorus (TP), Inorganic Phosphorus (IP), and Organic Phosphorus (OP) Distributions

1. The TP content of individual horizons ranged from a minimum of 188 ppm to a maximum of 1045 ppm. The mean and weighted averages were 525 ppm and 517 ppm, respectively. Surface sample results were not included in these calculations.

2. Some of these profiles had well-expressed eluviated and illuviated zones of TP. Generally, the TP curves reached a minimum at 50 cm and increased with depth to the depth sampled. The I/E ratio ranged from 1.1 to 3.6 averaging 1.5.

3. The Colo soils sampled that were adjacent to predominantly forested regions of northeastern Iowa had higher weighted averages TP in the 0-130 cm zone than the Colo soils collected in predominantly prairie or transitional areas of the state.

4. Generally, organic phosphorus/total phosphorus (OP/TP) ratios decreased with increasing soil depth. This is an indication of decreasing amounts of OP which would be

expected with decreasing amounts of total carbon.

5. Generally, the organic carbon/organic phosphorus (OC/OP) ratio was below 100 for the Colo horizons analyzed.

6. Generally, OC/OP ratio weighted averages were lower in the groups associated with southern Iowa, Missouri, and Illinois than other areas sampled.

Total Carbon (TC) Distribution

1. The highest group weighted average was in the F group and the lowest weighted average was in the Missouri group.

2. Overwash was present in some profiles as indicated by lighter soil matrix color and lower TC content.

3. TC content was affected by soil temperature as indicated by lower amount of TC in the Missouri group (highest) as compared to the Minnesota group (lowest).

Total Potassium (TK) and Available Potassium (STAVK) Distribution

1. TK content in the Colo groups was lower in low rainfall areas and higher in high rainfall areas.

2. The Colo soils from Champaign County, Illinois had a relatively high weighted average TK content as compared to the low peak height of illite.

3. All Colo soils had greater amounts of STAVK in the 0-20 cm zone than in the 30-61 cm zone.

4. Subsoil amounts of STAVK were similar between principal upland soils and Colo soils in the following groups: GPS, CKL, OMT, TM, and DT. The subsoil amounts were not similar to the subsoil amounts in the principal upland soil in other groups.

Clay Mineralogy

1. INTERST or mixed layer clay minerals were the dominant minerals in the majority of the Colo soils in this study based on relative peak heights. Montmorillonite, kaolinite-chlorite and illite are minor clay minerals as interpreted by relative peak heights.

2. The type of clay minerals within the Colo soils changed slightly with depth.

3. To determine the effect of precipitation and temperature the clay mineralogy of a Colo soil in northwestern Iowa (Lyon County) was compared to the clay mineralogy of a Colo soil in southeastern Iowa (Lee County). Both soils had increasingly well-defined clay mineral peaks with increasing soil depth. The types of clay minerals present were similar.

Morphological Properties

1. Several profiles had a B horizon described.

2. The moist matrix colors of the A horizon ranged from N 2/0 to 10YR 3/2.

3. The moist matrix colors of the B horizon ranged from 10YR 3/1 to 10YR 5/1.

4. The depth to gray mottles ranged from 23 cm to greater than 152 cm.

Classification

1. Approximately 1/3 of the Colo soils had weighted average clay content in the control section of more than 35% which is outside the range for the fine-silty family textural class.

2. Three soils had mollic epipedons less than 91 cm thick and four soils had pH values which exceeded the allowable range.

3. All other profiles studied met the requirement for a fine-silty, mixed, mesic, Cumulic Haplaquoll.

Models

Statistical models were developed in several ways. Several dependent and independent variables were used. Simple correlation coefficients between chemical, physical, mineralogical, and landscape variables were computed. In some cases, if $r \geq \pm .60$, one of the variables was dropped from the model equation. Other models were developed using variables that other researchers have used to aid in better understanding soil genesis. The model equations are presented in the text.

CONCLUSIONS

Jenny's five soil forming factor equation has been used as a model to describe or explain the genesis of soils. This equation has practical application to soils that have developed in a parent material in which deposition has ceased, e.g., glacial till, loess. It is more difficult to apply the equation to soils formed in alluvial sediments. This may indicate the development of these soils is more complex. The variations in soil properties may be the result of many different genetic pathways of development. Some of the Colo soils are on young geomorphic surfaces indicated by the presence of recent alluvial sediments (overwash). These surfaces, and the soil developed on them, may not be in equilibrium with their environment. The chemical and physical properties depth distributions are variable and the range in these Colo soils is difficult to define.

The ranges in characteristics used to define the Colo soil series are adequate, even though some profiles sampled at the type location are outside the range for the weighted average clay content in the control section. About 1/3 of the profiles had weighted average clay contents in the control section that were greater than 35%. These profiles should be re-evaluated especially those mapped before the mid-1960s. More sand and clay was allowed in the profile at that time.

The presence of overwash is difficult to recognize in many Colo soils. The thickness of the dark colored (10YR 2/1, 3/1) overwash has been used in calculating the required thickness of the mollic epipedon. This is not correct. The overwash in these soils should be recognized as post-cultural soil material and mapped as a phase (if 46 cm or less thick) of the Colo soil series.

Morphologically, the Colo soil is poorly drained. This study indicates that the Colo soils mapped in Nebraska may not be as poorly drained as those in Iowa.

Clay mineralogical analyses indicated a dominance of interstratified clay minerals. This would be expected considering the source of the alluvial sediments.

Statistical model equations developed with several chemical, physical, mineralogical, and landscape parameters explained some of the relationships between and among soil profiles. Landscape parameters indexed were useful but should be investigated more thoroughly in future studies. Additional landscape and soil parameters would be helpful in explaining more of the variation in alluvial-derived soils.

SUGGESTIONS FOR ADDITIONAL RESEARCH

This research project should be continued. Future research involving more models could be developed using many other soil and landscape variables, e.g., clay mineral peak height, sand content, coarse silt/fine silt ratio, geometric mean diameter, cation exchange capacity, width of stream, and elevation of upland and site. Quadratic and cubic multiple regression equations should be studied involving more samples at greater depths. Morphological properties, for example, the moist and dry matrix, color of the A and B horizons may be statistically correlated with the TC content. Soil structure, especially the distinctness and durability of the peds may be related to the clay content in the Colo soils. Complete chemical, physical, and mineralogical properties within the profile could be studied in detail. Field investigations could include studying profile variations on a grid matrix in the field sampled. Crop yield data could be obtained in different areas of the NCR to determine if crop yield is influenced more by soil properties or environmental properties. Presently, very little comparable crop yield data for Colo soils are available in the NCR.

Soils derived in alluvial sediments are variable in some soil properties and seem to have their own genetic pathways. Few chemical, physical, or morphological properties are inherited from associated upland soils. More studies are needed to characterize alluvial-derived soils because of the complexity of their genesis.

LITERATURE CITED

Alexander, J. D., J. B. Fehrenbacher, and D. C. Hallbick. 1974. Soil survey: Champaign-Urbana area, Illinois. Illinois Agricultural Experiment Station, Urbana, Illinois.

Arneman, H. F. 1960. Soil survey of Dakota County Minnesota. U.S. Government Printing Office, Washington, D.C.

Arnold, R. W. 1965. Multiple working hypotheses in soil genesis. Soil Sci. Soc. Am. Proc. 29: 717-725.

Atkins, P. W. 1978. Physical chemistry. W. H. Freeman and Company, San Francisco, California.

Barr, A. J., J. H. Goodnight, J. P. Sall, and J. T. Helwig. 1976. A user's guide to SAS 76. SAS Institute, Inc., Raleigh, North Carolina.

Bettis, E. A. 1979. Soil formation in Indian Mounds built from different parent materials in northeast Iowa. Unpublished M.S. thesis. Library, Iowa State University, Ames, Iowa.

Birchett, J. R. 1974. Plant-available and chemically extractable P in selected Iowa profiles developed in deep loess. Unpublished Ph.D. dissertation. Library, Iowa State University, Ames, Iowa.

Bray, R. H., and L. T. Kurtz. 1945. Determination of total and available forms of phosphorus in soils. Soil Sci. 59: 39-45.

Buol, S. W., F. D. Hole, and R. M. McCracken. 1973. Soil genesis and classification. Iowa State University Press, Ames, Iowa.

Carroll, D. 1970. Clay minerals: A guide to their x-ray identification. Special Paper 126. Geological Society of America, Boulder, Colorado.

Castro-Morales, L. A. 1978. Soil moisture and soil temperature regimes of some Iowa soils. Unpublished M.S. thesis. Library, Iowa State University, Ames, Iowa.

Cline, M. G. 1961. The changing model of soil. Soil Sci. Soc. Am. Proc. 25: 442-445.

Coffey, G. M. 1912. A study of the soils of the United States. U.S.D.A. Bureau of Soils Bulletin 85.

Coleman, T. L. 1980. The influence of stratigraphy and landscape position in the genesis of upland loess-derived soils of southern Iowa. Unpublished Ph.D. dissertation. Library, Iowa State University, Ames, Iowa.

Collins, M. E. 1977. Comparison of soil survey techniques in Tama County, Iowa 1905, 1950, 1977. Unpublished M.S. thesis. Library, Iowa State University, Ames, Iowa.

Corliss, J. F. 1958. Genesis of loess-derived soils in southeastern Iowa. Unpublished Ph.D. dissertation. Library, Iowa State University, Ames, Iowa.

Cummins, J. F. 1965. Soil survey of Waseca County, Minnesota. U.S. Government Printing Office, Washington, D.C.

Da Moude, D. W., D. Kerl, and N. L. Slama. 1975. Soil survey of Cuming County, Nebraska. U.S. Government Pringing Office, Washington, D.C.

Dick, W., and M. A. Tabatabai. 1977. An alkaline oxidation method for determination of total phosphorus in soils. Soil Sci. Soc. Am. 41: 511-514.

Dijkerman, J. C. 1974. Pedology as a science: The role of data, models and theories in the study of natural soil systems. Geoderma 11: 73-93.

Eik, K. 1980. Summary of soil test results. Cooperative Extension Service, Iowa State University, Ames, Iowa.

Elder, J. A., T. E. Beesley, and W. E. McKinzie. 1965. Soil survey of Saunders County, Nebraska. U.S. Government Printing Office, Washington, D.C.

Fenton, T. E., F. F. Riecken, and J. E. Seaholm. 1967. Effect of vegetation on total phosphorus distribution in some Iowa soils. Agron. Abstr. 1967: 117.

Ghaffarzadeh, M. 1979. Factors influencing available potassium level in the subsoil horizons of Iowa soils. Unpublished M.S. thesis. Library, Iowa State University, Ames, Iowa.

Godfrey, C. 1951. Distribution and nature of phosphorus in a geo-chrono-sequence of loess-derived soils. Unpublished Ph.D. dissertation. Library, Iowa State University, Ames, Iowa.

Godfrey, C. F., and F. F. Riecken. 1954. Distribution of phosphorus in some genetically related loess-derived soils. Soil Sci. Soc. Am. Proc. 18: 80-84.

Greenawalt, R. D., and W. E. McKinzie. 1964. Soil survey of Washington County, Nebraska. U.S. Government Printing Office, Washington, D.C.

Hack, J. T. 1960. Interpretation of erosional topography in humid temperate regions. Am. J. Sci. 258-A: 80-97.

Hallberg, G. R., T. E. Fenton, T. J. Kemmis, and G. A. Miller. 1980. Yarmouth revisited. Guidebook 27th Field Conference. Midwest Friends of the Pleistocene, May 30-June 1, 1980.

Harmon, L., and E. R. Duncan (eds.). 1978. A technical assessment of nonpoint pollution in Iowa. Work Element 503. College of Agriculture, Iowa State University, Ames, Iowa.

Henao, J. 1976. Soil variables for regressing Iowa corn yield on soil, management, and climatic variables. Unpublished Ph.D. dissertation. Library, Iowa State University, Ames, Iowa.

Hudelson, G. W. 1974. Soil survey of Logan County, Illinois. U.S. Government Printing Office, Washington, D.C.

Hutton, C. E. 1948. The morphology and genesis of prairie soils developed from Peoria loess in southwestern Iowa. Unpublished Ph.D. dissertation. Library, Iowa State University, Ames, Iowa.

Jackson, M. L. 1958. Soil chemical analysis. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Jeffrey, A. H. 1974. Soil survey of Caldwell County, Mo. U.S. Government Printing Office, Washington, D.C.

Jeffrey, A. H. 1975. Soil Survey of Lafayette County, Missouri. U.S. Government Printing Office, Washington, D.C.

Jenny, H. 1941. Factors of soil formation. McGraw-Hill Book Co., Inc., New York.

Jenny, H. 1961. Derivation of state factor equations of soils and ecosystems. Soil Sci. Soc. Am. Proc. 25: 385-388.

Kilmer, V. J., and L. T. Alexander. 1949. Methods of making mechanical analysis of soils. Soil Sci. 68: 15-24.

Kosse, A. D. 1966. Organic phosphorus/organic carbon ratios and natural drainage class in soils. Unpublished M.S. thesis. Library, Iowa State University, Ames, Iowa.

Kovar, J. A. 1967. Relation of nonexchangeable potassium and magnesium to development in some Iowa soils. Unpublished Ph.D. dissertation. Library, Iowa State University, Ames, Iowa.

Kuehl, R. J. 1978. Chemical and morphological properties of some loess-derived soils of northeast Iowa. Unpublished M.S. thesis. Library, Iowa State University, Ames, Iowa.

Larimer, O. J. 1974. Drainage areas of Iowa streams. U.S. Geological Survey, Water Resources Division, Bulletin No. 7.

Legg, J. O., and C. A. Black. 1955. Determination of organic phosphorus in soils: II. Ignition method. Soil Sci. Soc. Am. Proc. 19: 139-143.

Leighton, M. M., and J. A. Brophy. 1961. Illinoian glaciation in Illinois. J. Geol. 69: 1-31.

Leighton, M. M., G. E. Ekblaw, and L. Horberg. 1948. Physiographic divisions of Illinois. Illinois State Geology Survey Report of Investigations No. 129.

Leopold, L. B., and W. B. Langbein. 1962. The concept of entropy in landscape evolution. U.S. Geol. Survey Pro. Paper 500-A.

Mather, J. R., and C. W. Thornthwaite. 1964. Average climatic water balance data of the continents. Pub. XVII, No. 3, Part VII. C. W. Thornthwaite Associates Laboratory, Centerton, New Jersey.

McKim, H. 1972. Porosity and iron relationships in loessial prairie soils of southern Iowa. Unpublished Ph.D. dissertation. Library, Iowa State University, Ames, Iowa.

Miller, G. A. 1974. Soil parent material, stratigraphy and soil development, Cedar County, Iowa. Unpublished Ph.D. dissertation. Library, Iowa State University, Ames, Iowa.

Minor, P. E. 1979. Soil survey of Harrison County, Missouri. U.S. Government Printing Office, Washington, D.C.

Oparaugo, S. 1979. Soil-landscape relationship in selected loess derived soils of Carroll and Jasper Counties in Iowa. Unpublished M.S. thesis. Library, Iowa State University, Ames, Iowa.

Oschwald, W. R., F. F. Riecken, R. I. Didericksen, W. H. Scholtes, and F. W. Schaller. 1965. Principal soils of Iowa. Iowa State University Coop. Ext. Serv. Special Report No. 42.

Pearson, R. W., R. Spry, and W. H. Pierre. 1940. The vertical distribution of total and dilute acid soluble phosphorus in 12 Iowa soil profiles. J. Am. Soc. Agron. 32: 683-693.

Pena-Olvera, B. V. 1979. Corn yield in relation to soil, management, and weather variables in western Iowa. Unpublished Ph.D. dissertation. Library, Iowa State University, Ames, Iowa.

Poch, G. A. 1976. Soil survey of Goodhue County, Minnesota. U.S. Government Printing Office, Washington, D.C.

Ruhe, R. V. 1969. Quaternary landscapes in Iowa. Iowa State University Press, Ames, Iowa.

Ruhe, R. V., and W. H. Scholtes. 1956. Ages and development of soil landscapes in relation to climatic and vegetational changes in Iowa. Soil Sci. Soc. Am. Proc. 20: 264-273.

Ruhe, R. V., R. B. Daniels, and J. G. Cady. 1967. Landscape evolution and soil formation in southwestern Iowa. U.S.D.A. Tech. Bull. 1349.

Ruhe, R. V., M. Rubin, and W. H. Scholtes. 1957. Late pleistocene radiocarbon chronology in Iowa. Am. J. Sci. 255: 671-689.

Runge, E.C.A. 1963. Influence of natural drainage on iron and phosphorus distribution in some Iowa soils. Unpublished Ph.D. dissertation. Library, Iowa State University, Ames, Iowa.

Runge, E.C.A. 1973. Soil development sequences and energy models. Soil Sci. 115: 183-196.

Runge, E.C.A., and F. F. Riecken. 1966. Influence of natural drainage on the distribution and forms of phosphorus in some Iowa prairie soils. Soil Sci. Soc. Am. Proc. 30: 624-630.

Ryan, P. 1959. Morphology and extent of Muscatine and Tama soil series in Muscatine County, Iowa. Unpublished M.S. thesis. Library, Iowa State University, Ames, Iowa.

Salih, H. M. 1979. Factors influencing available phosphorus level in the subsoil horizons of Iowa soils. Unpublished M.S. thesis. Library, Iowa State University, Ames, Iowa.

Sawhney, B. J. 1977. Interstratification in layer silicate. In Minerals in soil environments. Soil Sci. Soc. Am. Inc., Madison, Wisconsin.

Shrader, W. D. 1950. Differences in the clay contents of surface soils developed under prairie as compared to forest vegetation in the central United States. Soil Sci. Soc. Am. Proc. 15: 333-337.

Simonson, R. W. 1959. Outline of a generalized theory of soil genesis. Soil Sci. Soc. Am. Proc. 23: 152-156.

Simonson, R. W., F. F. Riecken, and G. D. Smith. 1952. Understanding Iowa soils. Wm. C. Brown Co., Dubuque, Iowa.

Smeck, N. E. 1973. Phosphorus: An indicator of pedogenetic weathering processes. Soil Sci. 15: 199-206.

Smeck, N. E., and E.C.A. Runge. 1971. Phosphorus availability and redistribution in relation to profile development in an Illinois landscape segment. Soil Sci. Soc. Am. Proc. 35: 952-959.

Smith, G., W. Allaway, and F. F. Riecken. 1950. Prairie soils of the Upper Mississippi Valley. Adv. Agron. 2: 157-205.

Soil Survey Staff. 1951a, 1953, 1975a, and 1978. Official series descriptions for the Colo soil series. Author, Washington, D.C.

Soil Survey Staff. 1951b. Soil survey manual. U.S.D.A. Handbook No. 18.

Soil Survey Staff. 1975b. Soil taxonomy. U.S.D.A. Agr. Handbook No. 436.

Tabatabai, M. A., and J. M. Bremner. 1970. Use of the Leco automatic 70-second carbon analyzer for total carbon analysis of soils. Soil Sci. Soc. Am. Proc. 34: 608-610.

Tembhare, B. 1973. Available and inorganic forms of phosphorus in selected Alfisols and Mollisols. Unpublished Ph.D. dissertation. Library, Iowa State University, Ames, Iowa.

Thiel, G. A. 1956. Geology and underground waters of southern Minnesota. Minnesota Geol. Surv. Bull. 31.

Visher, S. S. 1954. Climatic atlas of the United States. Harvard University Press, Cambridge, Massachusetts.

Walker, P. H. 1966. Postglacial environments in relation to landscape and soils on the Cary Drift, Iowa. Iowa Agric. Exp. Sta. Res. Bull. 549: 838-875.

Walter, N. F., G. R. Hallberg, and T. E. Fenton. 1978. Particle-size analysis by the Iowa State University Soil Survey Laboratory. In G. R. Hallberg (ed.) Standard procedures for evaluation of Quaternary materials in Iowa. Tech. Inf. Series 8: 75-109. Iowa Geological Survey, Iowa City, Iowa.

Watson, F. C. 1975. Soil survey of Scotland County, Missouri. U.S. Government Printing Office, Washington, D.C.

Wells, K. L. 1963. Potassium and stages of development relationships in some loess-derived soils of Iowa. Unpublished Ph.D. dissertation. Library, Iowa State University, Ames, Iowa.

White, E. M., and F. F. Riecken. 1955. Brunizem-Gray-Brown Podzolic soil biosequence. Soil Sci. Soc. Am. Proc. 19: 504-509.

Wickham, J. T. 1979. Glacial geology of north-central and western Champaign County, Illinois. Illinois State Geol. Surv. Div. Circ. 506.

Worcester, B. K. 1973. Soil genesis on the stable primary divides of the southwestern Iowa loess sequence. Unpublished Ph.D. dissertation. Library, Iowa State University, Ames, Iowa.

Wright, H. E., and D. G. Frey (ed.) 1965. Glaciation of Minnesota and Iowa. In Quaternary of the United States. Princeton University Press, Princeton, New Jersey.

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APPENDIX A: SOIL PROFILE DESCRIPTIONS

Glossary of Terms for Soil Profile Descriptions

The following is a list of terms, symbols and abbreviations used in the descriptions of the soil profiles.

Horizon: Standard horizon nomenclature (U.S. Soil Survey Staff, 1951b, p. 139).

Depth: In centimeters measured from the top of the A horizon.

Color: The mathematical notations are taken from the Munsell Color Charts. Colors are for moist conditions unless specified dry. Intergrades of color are reported by a hyphen, i.e., 10YR 2/1-2/2 or 7.5YR 5/6-10YR 5/6. When two colors exist, they will be separated by the word "and" or "+", with the most abundant color first, i.e., 10YR 2/1 and 10YR 4/2.

Texture: Standard nomenclature (U.S. Soil Survey Staff, 1951b, p. 139).

lgt - light   hvy - heavy

Structure: Standard nomenclature (U.S. Soil Survey Staff, 1951b, p. 140), except when two size grades or types exist, they will be separated by a - or or +.

<u>Grade</u>
vwk - very weak
wk - weak
mod - moderate
str - strong

<u>Size</u>
vfi - very fine
fi - fine
med - medium
co - coarse

<u>Type</u>
gran - granular
mass - massive
clod - cloddy
prism - prismatic
pl - platy
ang - angular blocky
sbk - subangular blocky
→ - breaking to

Mottling: A description of colors and patterns are used. Colors are given in terms of the Munsell nomenclature. Patterns are as follows:

Abundance	Size	Contrast
f - few	fi - fine	fa - faint
c - common	med - medium	d - distinct
m - many	co - coarse	p - prominent

Note: Patterns are noted as follows: abundance, size, contract, i.e., c fi d

Consistence: Nomenclature as given, for moist conditions, except the 4-7" depth of site 21. It is for dry condition.

vfri - very friable
fri - friable
sl fir - slightly firm
fir - firm
v fir - very firm

Reaction: Given in units of pH.

Boundary (bdy): Standard nomenclature (U.S. Soil Survey Staff, 1951b, p. 139).
Except

Distinctness	Topography
abr - abrupt	sm - smooth
cl - clear	
g - gradual	
d - diffuse	

Abbreviations:

car - carbonates
lar - large
gry - grainy
cont - continuous
disc - discontinuous
cts - coats
mot - mottles
mn - manganese
conc - concretion
mix - mixings
stk - streaks
knd - kneaded
incr - increase
decr - decrease
Ex - exterior
In - interior
ox - oxides
w/ - with
\+ - and
accum - accumulations

Lithologic discontinuities: Roman numerals are preferred to the horizon designation to indicate a geologic distinction. The Roman numeral I can be omitted because it is understood that all that material is I. It is when a second horizon of contrasting material is observed that a II is used.

Soil: 1
County: Adair
Location: 86 meters W & 39 meters S of NE corner of sec. 33, T75N, R33W
N. veg. (or crop): Corn
Physiography: Floodplain of the Nodaway River
Gr. water: >152 cm

Horizon	Depth (cm)	Description
Ap	0-18	10YR 2/2 w/10YR 2/1 cts, 10YR 5/3 silty areas, 10YR 2/2 dry, sicl, clod → wk med gran, fri, pH 5.8, abr sm bdy
A12	18-36	10YR 2/2 w/10YR 2/1 cts, 10YR 3/2 dry, lgt sicl, wk fi gran, fri, pH 5.9, cl sm bdy
A13	36-61	10YR 2/2 w/10YR 2/1 cts, 10YR 2/1 dry, 10YR 6/1 silt cts dry, lgt sicl, wk fi gran, fri, pH 5.7, cl sm bdy
B1	61-84	10YR 2/1, 10YR 4/1 dry, f fi fa 7.5YR 4/6 Fe ox, hvy sicl, wk fi prism → wk fi sbk fri, pH 5.7, cl sm bdy
B21	84-102	N 2/0, 10YR 4/1 dry, f fi fa 7.5YR 4/6 Fe ox, lgt sic, wk fi prism → wk med sbk, lgt sic, fri, pH 5.6, cl sm bdy
B22	102-117	10YR 3/1, 10YR 4/1 dry, f fi fa 7.5YR 4/6 Fe ox, lgt sic, wk med sbk, fri, pH 5.8, cl sm bdy
B23	117-137	10YR 4/1, 10YR 5/1 dry, f fi fa 7.5YR 4/6 Fe ox, lgt sic, wk med sbk, fri, pH 5.7, cl sm bdy
C	137-152	10YR 4/1, 10YR 5/1 dry, hvy sicl, mass, fri, pH 5.9

Soil: 4
County: Appanoose
Location: 28 m W & 160 m N SE¼ SE¼ of sec. 5, T68N, R18W
N. veg. (or crop): Weeds
Physiography: Floodplain of Cooper Creek
Gr. water: >152

Horizon	Depth (cm)	Description
A11	0-13	10YR 2/1, hvy sil, wk fi & med sbk, fri, pH 7.0, g sm body
A12	13-28	10YR 2/1, lgt sicl, wk fi & med sbk & gran, fri, pH 6.9, g sm bdy
B21	28-43	10YR 2/1, sicl, wk co prism → wk & med fi & med sbk, fri, pH 6.1, g sm bdy
B22	43-59	10YR 2/1, w/f fi fa 7.5YR 4/6 Fe ox, sicl, mod co prism → wk med sbk, fri, pH 5.7, g sm bdy
B23	59-79	10YR 2/1 w/f fi fa 7.5YR 5/6 Fe ox, sicl, mod co prism → mod & wk med sbk, fri, pH 5.7, g sm bdy
B3	79-94	10YR - 7.5YR 3/1 w/c fi d 7.5YR 4/6 & f fi fa 7.5YR 5/6 (more prominent in lower part of horizon) Fe ox,sicl, wk co prims → wk med sbk, fri, pH 5.7, g sm bdy
BCg	94-130	10YR 3/1 & 10YR 4/1 (increase in lower part of the horizon) w/c med d 7.5YR 4/6 & f fi fa 2.5YR 4/6 & 7.5YR 5/6 mottles, hvy sil, wk co prism → wk co sbk & mass, fri, pH 5.7, cl sm bdy
Cg	130-152	10YR 4/1 & 5/1 w/c med d 7.5YR 5/6 & c fi fa 10YR 5/6 mottles, hvy sil, mass, fri, pH 6.0

Notes: In the area where this color profile was sampled no ground water was measured. In adjacent areas, water was on the surface. The cornfield was saturated.

Soil: 5
County: Audubon
Location: 3.2 kilometers S of Exira; 393 meters S and 108 meters E of the center of sec. 8, T78N, R35W
N. veg. (or crop): Cultivated
Physiography: Floodplain of the East Nishnobotna
Gr. water: 100-300 cm

Horizon	Depth (cm)	Description
Ap	0-23	N 2/0, 10YR 2/1 dry, lgt sicl, wk fi sbk → wk fi gran fri, pH 6.5, abr sm bdy
A12	23-48	10YR 2/1, 10YR 3/1 dry, sicl, wk fi sbk → mod med gran, fri, pH 5.5, d sm bdy
A13	48-84	10YR 3/1, 10YR 4/1 dry, sicl, wk fi sbk, fri, pH 5.5, d sm bdy
B	84-112	10YR 3/1, 10YR 4/1 dry, sicl, wk med prism → mod fi sbk & abk, fri, f fi soft accum (Fe + Mn ox), pH 5.9, g sm bdy
C1	112-132	10YR 3/1, sicl, mass, fri, f fi soft accum (Fe + Mn ox), pH 5.8, g sm bdy
C2	132-157	10YR 3/1, (Fe + Mn ox), hvy sicl, mass, fir, f fi soft accum, pH 6.2

Soil: 6
County: Benton
Location: 25.5 meters N and 42 meters W of the SE corner of the SE¼ NE¼ of sec. 16, T86N, R11W
N. veg. (or crop): Corn--recently seeded
Physiography: Floodplain of Spring Creek
Gr. water: 102 cm

Horizon	Depth (cm)	Description
Ap	0-18	10YR 2/1, 10YR 3/2 dry, lgt sicl, wk fi gran, fri, pH 6.1, abr sm bdy
A12	18-33	10YR 2/1, 10YR 3/2 dry, lgt sicl, wk fi prism → mod med sbk, fri, pH 6.0, abr sm bdy
A13	33-61	N 2/0, 10YR 2/1 dry, mod fi gran, fri, sicl, pH 5.8, cl sm bdy
B21	61-79	N 2/0, 10YR 3/1 dry, hvy sicl, mod med sbk → wk fi gran, fri, pH 6.1, cl sm bdy
B22	79-91	10YR 3/1, 10YR 3/1-4/1 dry, hvy sicl, mod med sbk → wk fi gran, fri, pH 6.2, abr sm bdy
B3g	91-102	10YR 3/1 & 4/1, 10YR 5/1 & 6/1 dry, sicl, mod med sbk → wk fi gran, fri, pH 6.2, abr sm bdy
Ab	102-112	N 2/0, 10YR 2/1 dry, sicl, wk med sbk, fri, pH 6.3, cl sm bdy
C1g	112-135	2.5 Y 5/2, 10YR 6/2 & 10YR 5/1, 10YR 7/2 dry, lgt sicl, c med d 10YR 5/6 mottles, hvy sil, wk med sbk, fri, pH 6.4, cl sm bdy
C2g	135-152	2.5Y 5/2, 10YR 6/1 & 7/2 dry, c med d, 10YR 5/6 mottles, hvy sil, mass, fri, pH 6.4

Soil: 16
County: Cedar
Location: 30 meters S and 200 meters W of the NE¼ corner of sec. 1, T81N, R3W
N. veg. (or crop): corn
Physiography: Floodplain of Rock Creek
Gr. water: 123 cm

Horizon	Depth (cm)	Description
Ap	0-23	N 2/0 & 10YR 2/1, 10YR 3/2 dry, lgt sicl, clod → wk med sbk & wk fi gran, fri, pH 6.3, abr sm bdy
A12	23-43	N 2/0, 10YR 2/1 dry, lgt sicl, wk fi gran, fri, pH 6.0, cl sm bdy
A13	43-61	N 2/0, 10YR 3/1 dry, lgt sicl, wk fi gran, fri, pH 6.1, cl sm bdy
B2	61-71	10YR 2/1 & 3/1, 10YR 5/1 dry, hvy sil, wk med sbk & wk fi gran, fri, pH 6.3, abr sm bdy
B31g	71-84	10YR 2/1 & 2.5Y 5/2, 10YR 5/1 & 6/2 dry, f fi fa 7.5YR 5/6 mottles, hvy sil, wk fi prism → mod med sbk, fri, pH 6.4, abr sm bdy
B32g	84-104	2.5Y 5/2 & 10YR 4/1, 10YR 7/1 dry, f fi fa 7.5YR 5/6 mottles, sil, wk med sbk, fri, pH 6.5, cl sm bdy
Cg	104-123	2.5Y 5/2 & 10YR 4/1, 10YR 7/1 dry, f fi p 7.5YR 5/6 mottles, f fi fa 5YR 2.5/2 & 2.5/1 Mn ox, at 118 cm c fi d 5YR 3/3 Fe ox & c med p 7.5YR 5/6 mottles, sil, wk med sbk, fri, pH 6.6

Note: Type location for Colo was across the gravel road to the north in sec. 36 T82N, R3W.

Soil: 18
County: Cherokee
Location: 30.3 meters S & 60.6 meters W of bridge SE¼ sec. 24, T90N, R39W
N. veg. (or crop): corn
Physiography: Floodplain of Maple River
Gr. water: 127 cm

Horizon	Depth (cm)	Description
Ap	0-20	10YR 2/1, knd 10YR 2/2, hvy sicl, clod → wk fi & med sbk, fri, pH 5.8, abr sm bdy
A12	20-38	N 2/0, hvy sicl, wk co prism → wk fi & med sbk & gran, fri,pH 6.1, g sm bdy
A13	38-48	N 2/0, hvy sicl, wk co prism → wk fi med sbk & gran, fri, pH 6.2, g sm bdy
A14	48-61	N 2/0, hvy sicl, mod med prism → mod fi gran, fri, pH 6.8, g sm bdy
A15	61-76	10YR 2/1-3/;, hvy sicl, mod co prism → mod fi & med gran & sbk, fri, pH 7.2, g sm bdy
B21	76-102	10YR 2/1-3/1, sicl, mod co prism → mod fi & med sbk, fri, pH 7.6, g sm bdy
B22	102-112	10YR 3/1-2/1, knd 10YR 3/1, sicl, mod & str fi & med sbk, fri, pH 7.6, cl sm bdy
B23	112-132	10YR 3/1, sicl, str co prism → str med & co ang, fri, pH 7.5, cl sm bdy
Cg	132-152	10YR 4/1, sicl, mass, fri, pH 7.4

Soil: 21
County: Clay
Location: 66 m S & 58 m W of NE corner of SW¼, NW¼, sec. 7, T96N, R37W
N. veg. (or crop) soybeans (corn residue)
Physiography: Floodplain of the Ocheyedan River
Gr. water: 130 cm

Horizon	Depth (cm)	Description
Ap	0-15	N 2/0, hvy sicl, clod → wk fi & med gran, fri, pH 5.7, g sm bdy
A12	15-23	N 2/0, hvy sicl, wk fi & med sbk & gran, fri, pH 6.0, g sm bdy
A13	23-38	N 2/0, hvy sicl, wk med sbk, fri, pH 6.5, g sm bdy
A14	38-53	N 2/0, hvy sicl, wk fi prism → wk med sbk, fri, pH 6.6, g sm bdy
B21	53-61	10YR 2/1, sicl, mod fi prism → wk med sbk, fri, pH 6.8, cl sm bdy
B22	61-71	10YR 3/1, sicl, mod med prism → wk fi & med sbk, fri, pH 6.9, cl sm bdy
B31	71-99	10YR 3/1 w/f fi fa 7.5 YR 4/4 Fe ox, sicl, mod med prism → wk med sbk, fri, pH 7.5, cl sm bdy
B32	99-109	10YR 3/1 w/f fi fa 7.5YR 4/4 fe ox, lgt sicl, wk med prism → wk med sbk, fri, pH 7.7, abr sm bdy
C1g	109-127	10YR 3/1-4/1 w/f fi fa 7.5YR 4/4, 10 YR 7/1 $CaCo_3$ accum, lgt cl, mass, fri, pH 7.8, cl sm bdy
C2g	127-150	10YR 4/1-3/1 w/10YR 7/1 $CaCO_3$ accum, lgt cl, mass, fri, pH 7.8
C3g	150-170	10YR 4/1, scl, mass, fi, pH 7.8

Notes: Increase in sand content in C2g horizon. The sand content in the C3g horizon is greater than in the C2g horizon. In this horizon the sand grains are visible to the naked eye. The profile is calcareous below 109 cm. Below 109 cm there are light grayish zones which are areas of secondary calcium carbonates.

Soil: 22-1
County: Clayton
Location: 55 m W & 43 m S of NE¼ of NW¼ sec. 36, T94N, R4W
N. veg. (or crop: permanent pasture
Physiography: Floodplain of the lower part of a major upland drainageway
Gr. water: 107 cm

Horizon	Depth (cm)	Description
A11	0-13	10YR 2/1, lgt sicl, wk fi gran, fri, pH 6.1, cl sm bdy
A12	13-43	10YR 2/1, sicl, mod fi gran, fri, pH 5.8, g sm bdy
B21	43-71	10YR 2/1, hvy sicl, mod fi gran and sbk, fri, pH 6.3, g sm bdy
B22	71-89	10YR 2/1, sicl, wk fi gran and sbk, fri, pH 6.5, g sm bdy
B23	89-109	10YR 2/1, sicl, wk fi gran and sbk, fri, pH 6.7, g sm bdy
B3	109-130	10YR 3/1 w/10YR 2/1 mix, sicl, wk fi gran, fri, pH 6.6, cl sm bdy
C1g	130-145	10YR 3/1 & 10YR 4/1 w/f 10YR 5/2 mix, f fi d 2.5Y 5/4 mottles, lgt sicl, mass, fri, pH 6.9, cl sm bdy
C2g	145-152	10YR 4/1 & 5/2, c med & 2.5Y 5/4 mottles, lgt sicl, mass, fri, pH 6.9

Soil: 22-2
County: Clayton
Location: 79 m N & 42 m W SE¼, NE¼, SW¼ of sec. 4, T93N, R4W
N. veg. (or crop): Alfalfa hay
Physiography: Floodplain of Dry Mill Creek
Gr. water: 66 cm

Horizon	Depth (cm)	Description
Ap	0-20	N 2/0, sicl, wk fi gran, fri, pH 6.8, abr sm bdy
A12	20-33	N 2/0, lgt sicl, mod fi gran, fri, pH 6.6, g sm bdy
A13	33-59	N 2/0, sicl, mod fi gran, fri, pH 6.6, g sm bdy
A14	59-74	10YR 2/1, lgt sicl, wk fi gran, fri, pH 6.8, g sm bdy
A15	74-94	10YR 2/1, sicl, wk fi gran & wk fi sbk, fri, pH 6.9, g sm bdy
AC	94-117	10YR 2/1-3/1, lgt sicl, wk fi sbk & mass, fri, pH 6.9, cl sm bdy
C1	117-127	10YR 3/1, lgt sicl, mass, fri, pH 7.1, cl sm bdy
C2g	127-140	2.5Y 5/2 w/f fi d 2.5Y 5/0 & 7.5YR 5/6, hvy sicl, mass, fri, pH 7.3, cl sm bdy
C3g	140-152	2.5Y 5/2 w/c fi d 2.5Y 5/0, sil, mass, fri, pH 7.4

Soil: 24
County: Crawford
Location: 2000 m W & 50 m S of NE corner of SE¼ sec. 1, T85N, R37W
N. veg. (or crop): Corn
Physiography: Floodplain of an unnamed tributary of the Boyer River
Gr. water: > 147 cm

Horizon	Depth (cm)	Description
Ap	0-18	10YR 2/1 10YR 3/2 & 3/1 dry w/10YR 3/3 & 3/2 areas, 10YR 2/2 knd, 10YR 6/2 silty areas, at 9 cm 7.5YR 4/4 fe ox in bands, hvy sicl, clod → wk med sbk, fri, pH 6.2, cl sm bdy
A12	18-33	10YR 2/1 w/10YR 3/3 areas, 10YR 3/2 & 3/1 dry, 7.5YR 4/4 fe ox in root channels, hvy sicl, wk med sbk & wk fi gran, fri, pH 5.5, abr sm bdy
A13	33-53	10YR 2/1, 10YR 3/1 dry, hvy sicl, wk fi gran, fri, pH 5.8, cl sm bdy
B1	53-74	10YR 2/1, 10YR 3/1 dry, hvy sicl, wk fi & med sbk, fri, pH 6.0, cl sm bdy
B21	74-84	N 2/0, 10YR 3/1 dry, hvy sicl, mod med prism → str vfi sbk, fri, pH 6.4, cl sm bdy
B22	84-104	N 2/0, 10YR 3/1 dry, hvy sicl, mod med prism → str fi & med sbk, fri, pH 6.8, cl sm bdy
B31	104-123	N 2/0, 10YR 3/1 dry, hvy sicl, wk med sbk, fri, pH 6.9, cl sm bdy
B32	123-135	N 2/0, 10YR 3/1 dry, lgt sicl, mod fi sbk, fri, pH 6.9, cl sm bdy
C	135-147	N 2/0, 10YR 3/1 dry, lgt sicl, wk & med fi sbk, fri, pH 7.0

Soil: 29
County: Des Moines
Location: 47 m N of center of concrete bridge, 7.5 m E from field edge, sec. 19, T72N, R4W
N. veg. (or crop): Corn
Physiography: Floodplain of Big Creek
Gr. water: > 152 cm

Horizon	Depth (cm)	Description
Ap	0-20	10YR 2/1, 10YR 4/1 dry, hvy l, clod → wk med sbk, fri, pH 7.1, abr sm bdy
A12	20-33	10YR 2/1 & N 2/0, 10YR 3/1-4/1 dry, lgt cl, wk fi sbk, fri, pH 6.9, cl sm bdy
A13	33-48	N 2/0, 10YR 3/1 dry, lgt cl, mod fi gran, fri, pH 6.6, cl sm bdy
A14	48-61	N 2/0, 10YR 2/1 dry, lgt cl,mod fi gran & sbk, fri, pH 6.6, cl sm bdy
B2	61-97	10YR 3/1, 10YR 3/1 dry, lgt cl, mod fi gran & sbk, fri, pH 6.8, cl sm bdy
B3	96-112	10YR 3/1, 10YR 4/1 dry, lgt cl, wk med sbk, fri, pH 6.7, cl sm bdy
BC	112-123	10YR 3/1, 10YR 4/1 dry, lgt cl, wk med sbk & mass, fri, pH 6.8, cl sm bdy
Cg	123-152	10YR 3/1, 4/1 & 2.5Y 5/4, 10YR 4/1, 5/1 & 6/1 dry, f fi fa 7.5YR 5/6 mottles, lgt cl, mass, fri, pH 6.8

Soil: 31-1
County: Dubuque
Location: 17 m N & 42 m W of NE¼, SE¼, sec. 12, T90N, R1W
N. veg. (or crop): Corn
Physiography: Floodplain (tributary of the North Fork of the Little Maquoketa River)
Gr. water: 130 cm

Horizon	Depth (cm)	Description
Ap	0-20	10YR 2/1, lgt sicl, mod fi gran, fri, pH 6.8, abr sm bdy
A12	20-36	10YR 2/1, lgt sicl, mod fi gran, fri, pH 7.0, g sm bdy
A13	36-51	10YR 2/1, lgt sicl, wk fi gran, fri, pH 7.0, g sm bdy
A14	51-74	10YR 2/1, lgt sicl, mod fi sbk, fri, pH 7.3, g sm bdy
A15	74-99	10YR 2/1, 10YR 3/1 in lower part, 10YR 2/1 mix, lgt sicl, wk fi sbk, fri, pH 7.4, g sm bdy
AC	99-124	10YR 3/1, f 10YR 4/1 mix, f med d 2.5Y 5/4 mottles, lgt sicl, vwk fi sbk & mass, fri, pH 7.4, cl sm bdy
Cg	124-152	10YR 4/1 w/f fi d 2.5Y 5/4 mottles, sil, mass, fri, pH 7.5

Notes: Some of the field is covered with overwash. This area has not been mapped as of 6/78. At 147 cm there are a few chert fragments. The field has been tiled.

Soil: 31-2
County: Dubuque
Location: 152 m N & 20 m W NE¼ NW¼ sec. 10, T87N, R1E
N. veg. (or crop): Corn
Physiography: Floodplain of Prairie Creek
Gr. water: 104 cm

Horizon	Depth (cm)	Description
Ap	0-20	10YR 2/1 w/ N 2/0 cts, lgt sicl, wk fi gran, fri, pH 5.4, abr sm bdy
A12	20-30	N 2/0, lgt sicl, mod fi gran, fri, pH 6.1, g sm bdy
A13	30-56	N 2/0, sicl, mod fi gran, fri, pH 6.3, g sm bdy
A14	56-71	N 2/0, lgt sicl, wk fi sbk, fri, pH 6.5, g sm bdy
A15	71-91	N 2/0, sicl, wk med sbk, fri, pH 6.5, g sm bdy
A16	91-107	N 2/0, lgt sicl, vwk med sbk, fri, pH 6.5, cl sm bdy
C1	107-132	10YR 3/1, lgt sicl, mass, fri, pH 6.6, g sm bdy
C2	132-152	10YR 3/1, lgt sicl, mass, fri, pH 6.6

Notes: Sampled bagged this profile every 5 cm to 105 cm. The soil adjacent to the creek (pasture) has overwash. The area has been tiled.

Soil: 36
County: Fremont
Location: 60 m W & 15 m S of NE corner of SE¼ sec. 12, T69N, R40W
N. veg. (or crop): Soybeans
Physiography: Floodplain of the East Nishnabotna River
Gr. water: 91 cm

Horizon	Depth (cm)	Description
Ap	0-18	10YR 2/1, 10YR 3/2 dry, 10YR 5/3 silty areas, hvy sicl, wk fi gran & sbk, fri, pH 5.9, abr sm bdy
A12	18-28	N 2/0, 10YR 3/1-3/2 dry, sicl, wk fi gran, fri, pH 6.0, cl sm bdy
A13	28-41	N 2/0, 10YR 3/1 dry, sicl, mod fi gran, fri, pH 6.2, cl sm bdy
A14	41-61	N 2/0, 10YR 3/1 dry, hvy sicl, mod fi gran, fri, pH 6.4, cl sm bdy
A15	61-79	N 2/0, 10YR 3/1 dry, sicl, wk fi prism → mod fi gran, fri, pH 6.5, cl sm bdy
B2	79-99	10YR 3/1, 10YR 3/1-4/1 dry, sicl, wk fi prism → mod fi sbk, fri, pH 6.6, cl sm bdy
B3g	99-140	10YR 4/1 int, 10YR 3/1 ext, 10YR 5/1-5/2 dry sicl, wk med & fi sbk, fri, pH 6.7, cl sm bdy
Cg	140-152	10YR 4/1 & few 10YR 3/1 cts, 10YR 5/2 & 5/1 dry, sicl, mass, fri, pH 6.7

Soil: 38
County: Grundy
Location: 127 m N, 135 m E of the bridge, SE¼ of NW¼, sec. 7, T87N, R16W
N. veg. (or crop): Corn
Physiography: Floodplain of Holland Creek
Gr. water: >145 cm

Horizon	Depth (cm)	Description
Ap	0-20	10YR 2/1, 10YR 3/1-2/1 dry, lgt sicl, clod → wk fi & med sbk & gran, fri, pH 6.5, abr sm bdy
A12	20-38	10YR 2/1, 10YR 2/1 dry, lgt sicl, wk fi & med gran, fri, pH 6.5, g sm bdy
A13	38-61	10YR 2/1, 10YR 2/1-3/1 dry, lgt sicl, wk co prism → wk fi & med gran, fri, pH 6.4, g sm bdy
B2	61-84	10YR 2/1, 10YR 3/1-4/1 dry, hvy sil, wk med prism → mod med sbk, fri, pH 6.4, cl sm bdy
B31	84-107	10YR 2/1-3/1, 10YR 3/1-4/1 dry, c med d & fi c d 7.5YR 4/6 fe ox, lgt sicl, mod med prism → wk med sbk, fri, pH 6.4, cl sm bdy
B32	107-122	N 2/0, 10YR 4/1 dry, lgt sicl, str co prism, fri, pH 6.3, g sm bdy
C	122-145	N 2/0, 10YR 4/1 dry, l, mass, fri, pH 6.4

Soil: 43
County: Harrison
Location: 60 m N and 300 m E of SW corner of NW¼ sec. 4, T79N, R42W
N. veg. (or crop): Soybeans
Physiography: Boyer River Floodplain
Gr. water: 91 cm

Horizon	Depth (cm)	Description
Ap	0-18	N 2/0, 10YR 2/1 dry, hvy sicl, wk fi gran & wk fi sbk, fri, pH 6.2, cl sm bdy
A12	18-38	N 2/0, 10YR 2/1 dry, sicl, wk fi gran, fri, pH 6.1, g sm bdy
A13	38-61	N 2/0, 10YR 2/1 dry, sicl, wk fi sbk, fri, pH 6.1, g sm bdy
B21	61-79	10YR 2/1, 10YR 4/1 dry, sicl, wk fi prism → wk fi & med sbk, fri, pH 6.0, cl sm bdy
B22	79-94	10YR 2/1, 10YR 4/1 dry, sicl, wk fi prism → wk fi & med sbk, fri, pH 6.0, cl sm bdy
B23	94-104	10YR 3/1 w/f 10YR 2/1 cts f fi fa 7.5YR 3/2 areas on ped faces, sicl, wk med sbk, fri, pH 6.1, cl sm bdy
B31	104-122	10YR 3/1, 10YR 4/1-4/2 dry, sicl, wk med sbk, fri, pH 6.1, cl sm bdy
B32	122-137	10YR 3/1, 10YR 5/1-5/2 dry sicl, wk fi & med sbk, fri, pH 6.2, cl sm bdy
C	137-152	10YR 4/2 w/10YR 3/1 cts 10YR 5/2 dry, sicl, wk fi sbk, fri, pH 6.2

Soil: 44
County: Henry
Location: 26 m W & 37.5 m N of field boundary SE¼, sec. 24, T72N, R5W
N. veg. (or crop): Permanent pasture
Physiography: Floodplain of Big Creek
Gr. water: 102 cm

Horizon	Depth (cm)	Description
A11	0-15	10YR 2/1, sicl, wk med sbk, fri, pH 6.8, abr sm bdy
A12	15-30	10YR 2/1, hvy sicl, str fi sbk, fri, pH 6.5, cl sm bdy
A13	30-43	N 2/0, hvy sicl, str fi sbk, fri, pH 6.5, cl sm bdy
A14	46-61	N 2/0, hvy sicl, mod med sbk, fri, pH 6.5, cl sm bdy
B21	61-81	N 2/0, hvy sicl, mod fi sbk, fri, pH 6.6, cl sm bdy
B22	81-99	N 2/0, hvy sicl, mod fi sbk, fri, pH 6.7, cl sm bdy
B23	99-123	N 2/0, hvy sicl, wk & mod fi sbk, fri, pH 6.7, abr sm bdy
B3g	123-140	10YR 4/1 & N 2/0, sicl, wk & mod fi sbk, fri, pH 6.8, abr sm bdy
Cg	140-152	2.5Y 5/2 & 10YR 3/1 w/f fi fa 7.5YR 4/6 fe ox, sicl, wk & med fi sbk, fri, pH 6.8

Soil: 48
County: Iowa
Location: 36 m E & 158 m N, NE¼, NE¼, sec. 18, T79N, R10W
N. veg. (or crop): Corn
Physiography: Floodplain of Hog Run
Gr. water: 123 cm

Horizon	Depth (cm)	Description
Ap	0-15	10YR 2/1, 10YR 2/2 knd, 10YR 4/2 dry, hvy sil, wk fi & med gran fri, pH 6.8, abr sm bdy
A12	15-30	N 2/0, 10YR 3/1 dry, lgt sicl, wk med sbk → wk fi gran, fri, pH 6.6, cl sm bdy
B1	30-61	N 2/0, 10YR 3/1 dry, hvy sicl, wk med sbk → wk fi gran, fri, pH 6.2, cl sm bdy
B21	61-89	N 2/0, 10YR 3/1-4/1 dry sicl, wk med sbk → wk fi gran & sbk, fri, pH 6.4, cl sm bdy
B31	89-109	10YR 2/1, 10YR 4/1 dry, f fi fa 7.5YR 4/6 fe ox, sicl, wk med sbk, fri, pH 6.8, cl sm bdy
B32	109-123	10YR 3/1, 10YR 4/1 & 5/1 dry, sicl, wk & med fi & med sbk, fri, pH 6.8, cl sm bdy
C1g	123-137	10YR 4/1, 10YR 4/1 dry, f fi fa 7.5YR 4/6 fe ox, lgt sicl, wk med sbk, fri, pH 6.9, cl sm bdy
C2g	137-152	10YR 4/1, 10YR 5/1 dry, lgt sicl, wk co sbk, fri, pH 6.9

Soil: 52
County: Johnson
Location: 81 m E & 79 m S of NW corner of SW¼, NW¼ of sec. 12, T77N, R5W
N. veg. (or crop: Permanent pasture
Physiography: Floodplain (?) drainage ditch 2
Gr. water: >122 cm

Horizon	Depth (cm)	Description
A11	0-18	10YR 2/1, 10YR 4/2 dry, knd 10YR 2/2, sil wk fi gran, fri, pH 6.0, abr sm bdy
A12	18-38	10YR 2/1, 10YR 3/2 dry, 10YR 4/3 silty areas, hvy sil, wk fi & med sbk, fri, pH 6.3, abr sm bdy
B21	38-61	N 2/0, 10YR 3/1 dry, hvy sicl, mod fi prism → mod vfi gran, fri, pH 6.4, cl sm bdy
B22	61-76	N 2/0, 10YR 3/1 dry, hvy sicl, mod fi prism → mod fi sbk, fri, pH 6.5, cl sm bdy
B23	76-94	10YR 3/1-2/1, 10YR 4/1 dry, f fi fa 7.5YR 4/6 fe ox, hvy sicl, wk fi prism → mod fi sbk, fri, pH 6.5, cl sm bdy
B3g	94-109	10YR 3/1-4/1, 10YR 4/1 dry, f fi fa 7.5YR 4/6 fe ox, sicl, wk fi prism → wk fi sbk, fri, pH 6.7, cl sm bdy
Cg	109-122	10YR 4/1, 10YR 4/1-5/1 dry, mod co p 7.5YR 4/6 fe ox, sicl, wk fi sbk, fri, pH 6.7

Soil: 54
County: Keokuk
Location: 2800 m S & 1200 m W NE corner of sec. 6, T77N, R13W
N. veg. (or crop) Corn
Physiography: Floodplain of South English River
Gr. water: >152 cm

Horizon	Depth (cm)	Description
Ap	0-20	10YR 2/1, 10YR 4/2 dry, w/10YR 6/2 silty areas, sil, wk fi & med sbk & gran, fri, pH 6.4, cl sm bdy
A12	20-36	10YR 2/1, 10YR 4/2-4/1 dry, w/10YR 6/2 silty areas, hvy sil, mod fi sbk, fri, pH 6.3, abr sm bdy
A13	36-66	10YR 2/1-N 2/0, 10YR 4/1 dry, lgt sicl, wk fi & med sbk & gran, fri, pH 5.8, g sm bdy
B1	66-91	10YR 2/1, 10YR 3/1-2/1 dry, hvy sicl, wk med prism → wk fi gran & sbk, fri, pH 5.8, g sm bdy
B21	91-104	10YR 3/1, 10YR 3/1 dry, hvy sicl, mod med prism → wk fi sbk, fri, pH 5.8, g sm bdy
B22g	104-123	10YR 4/1, 10YR 4/1-5/2 dry, f fi fa 10YR 5/2 & 7.5YR 5/6 mottles, hvy sicl, wk med prism → wk med sbk, fri, pH 5.9, abr sm bdy
B23g	123-135	10YR 4/1, 10YR 5/1 & 5/2 dry, c med p 7.5YR 5/6 mottles, hvy sicl, mod med prism → wk med sbk, fri, pH 5.8, cl sm bdy
B3g	135-152	10YR 5/1, 10YR 5/1 dry, f fi fa 10YR 6/1, mod med d 7.5YR 5/6 mottles, f co 2.5Y 2/2 Mn ox, sicl, mod med prism → wk med sbk, fri, pH 6.1

Soil: 56
County: Lee
Location: 93 m N & 36 m W of SE corner of SW¼ sec. 1, T69N, R7W
N. veg. (or crop): Corn
Physiography: Floodplain of Sugar Creek
Gr. water: >152 cm

Horizon	Depth (cm)	Description
Ap	0-23	10YR 2/1, 10YR 5/2 & 7/2 silty areas, lgt sicl, clod → wk fi & med sbk, fri, pH 6.1, cl sm bdy
A12	23-41	N 2/0, lgt sicl, wk fi gran & sbk, fri, pH 6.3, cl sm bdy
A13	41-61	N 2/0, lgt sicl, mod v fi sbk, fri, pH 6.4, cl sm bdy
B21	61-91	10YR 3/1, sicl, wk fi prism → mod med sbk, fri, pH 6.6, cl sm bdy
B22g	91-107	10YR 3/1-4/1 sicl, mod fi prism → mod med sbk, fri, pH 6.7, cl sm bdy
B23g	107-123	10YR 3/1-4/1, sicl, mod med sbk, fri, pH 6.9, cl sm bdy
B3g	123-135	10YR 3/1 & 4/1, f fi fa 10YR 4/4 mottles, sicl, wk med sbk, fri, pH 6.8, cl sm bdy
Cg	135-152	10YR 3/1, 4/1, 5/1, c med & fi d 7.5YR 5/6 mottles, hvy sicl, mass, fri, pH 6.8

Soil: 60
County: Lyon
Location: 30 m W & 135 m S of NE corner of SE¼, sec. 18, T99N, R46W
N. veg. (or crop): Corn
Physiography: Floodplain of Mud Creek
Gr. water: >145 cm

Horizon	Depth (cm)	Description
Ap	0-18	10YR 2/1, 10YR 3/1 dry, sicl, clod → wk med sbk, fri, pH 5.0, cl sm bdy
A12	18-38	10YR 2/1, 10YR 3/1 dry, sicl,, mod fi gran & mod med sbk, fri, pH 5.8, cl sm bdy
A13	38-71	10YR 2/1, 10YR 3/1-4/1 dry, sicl, mod fi gran & mod med sbk, fri, pH 6.8, cl sm bdy
A14	71-99	10YR 2/1, 10YR 3/1-4/1 dry, lgt sicl, wk fi gran & sbk, fri, pH 7.1, cl sm bdy
C1	99-123	10YR 3/1, 10YR 4/1 dry, sil, wk med sbk, fri, pH 7.3, cl sm bdy
C2	123-145	10YR 3/1, 10YR 4/1 dry, sil, wk fi & med sbk, fri, pH 7.3

Soil: 62
County: Mahaska
Location: 1584 m S & 396 m W, SW¼ NW¼ sec. 29, T74N, R14W
N. veg. (or crop): Pasture
Physiography: Floodplain of Cedar Creek
Gr. water: >152 cm

Horizon	Depth (cm)	Description
Ap	0-20	10YR 2/1, 10YR 4/1 dry, hvy sil, mod fi & med sbk, fri, pH 6.0, cl sm bdy
A12	20-41	10YR 2/1, 10YR 4/1 dry, hvy sil, wk fi gran & sbk, fri, pH 5.7, g sm bdy
A13	41-61	10YR 2/1, 10YR 4/1 dry, hvy sil, wk fi & med sbk, fri, pH 5.7, g sm bdy
A14	61-79	10YR 2/1, 10YR 3/1 dry,lgt sicl, wk fi prism → wk fi & med sbk, fri, pH 5.8, g sm bdy
B1	79-94	10YR 2/1, 10YR 3/1 dry lgt sicl, wk fi prism → wk & mod med sbk, fri, pH 5.9, g sm bdy
B21	94-107	10YR 2/1, 10YR 3/1 dry, f fi fa 7.5YR 5/6 mottles, hvy sicl, mod med prism → wk med sbk, fri, pH 5.9, g sm bdy
B22	107-119	10YR 2/1, 10YR 3/1 dry, f fi fa 7.5YR 5/6 mottles, hvy sicl, mod med prism → wk med sbk, fri, pH 6.0, g sm bdy
B3	119-136	10YR 3/1, 10YR 3/1 dry, f fi fa 7.5YR 5/6 mottles, hvy sicl, wk co prism, fri, pH 6.2
C	136-152	10YR 3/1, 10YR 3/1 dry, f fi fa 7.5YR 5/6 mottles, hvy sicl, wk co prism, fri, pH 6.0

Soil: 63
County: Marion
Location: 152 m W & 30 m N of SE corner of NE¼ of sec. 4, T77N, R20W
N. veg. (or crop): Corn
Physiography: Floodplain of Calhoun Creek
Gr. water: Approximately 84 cm

Horizon	Depth (cm)	Description
Ap	0-18	10YR 2/1, sil, wk fi gran & sbk, fri, pH 6.1, cl sm bdy
A12	18-33	10YR 2/1 w/f fi fa 10YR 4/3 mottles, hvy sil, wk med sbk, fri, pH 6.5, g sm bdy
B21	33-69	10YR 2/1, lgt sicl, mod med prism → wk & mod fi & med sbk & gran, fri, pH 6.6, g sm bdy
B22	69-81	10YR 2/1, sicl, wk med prism → wk med sbk, fri, pH 6.6, g sm bdy
B23	81-94	10YR 3/1, sicl, wk med prism → wk med sbk, fri, pH 6.8, g sm bdy
B3g	94-114	10YR 3/1-4/1, lgt sicl, wk med prism → mass, fri, pH 6.9, cl sm bdy
Cg	114-152	10YR 4/1, w/f fi fa 7.5YR 4/4 & 10YR 4/2 mottles, lgt sicl, mass, fri, pH 6.9

Notes: Very thin lense of sand in 0-3 cm.

Soil: 71
County: O'Brien
Location: 204 m S & 86 m E, NW¼, SW¼ sec. 31, T95N, R41W
N. veg. (or crop): Soybeans
Physiography: Floodplain of Mud Creek
Gr. water: Approximately 97 cm

Horizon	Depth (cm)	Description
Ap	0-13	10YR 2/1, hvy sicl, clod → wk fi & med sbk, fri, pH 6.0, cl sm bdy
A12	13-28	10YR 2/1, sicl, wk co prism → w med sbk, fri, pH 6.5, g sm bdy
A13	28-38	10YR 2/1, sicl, wk med prism, fri, pH 6.7, g sm bdy
B1	38-51	10YR 3/1, sicl, mod med prism → mod med sbk, fri, pH 7.2, g sm bdy
B21	51-66	10YR 3/1, sicl, mod med prism → mod med sbk, fri, pH 7.3, g sm bdy
B22	66-81	10YR 3/1, sicl, mod med prism → mod fi & med sbk, fri, pH 7.4, g sm bdy
B23	81-91	10YR 3/1, sicl, mod med prism → mod fi & med sbk, fri, pH 7.5, g sm bdy
B24	91-102	10YR 3/1, sicl, mod med prism → mod fi sbk, fri, pH 7.4, g sm bdy
B3g	102-112	10YR 3/1-4/1, sicl, wk & mod fi & med sbk, mass, fri, pH 7.8, g sm bdy
C1g	112-123	10YR 4/1 w/10YR 5/3 areas, f fi fa 7.5YR 4/4 fe ox, sicl, mass w/fract. faces, fri, pH 7.7, g sm bdy
C2g	123-130	10YR 4/1 w/10YR 5/3 areas, f fi fa 7.5 YR 5/0 fe ox, sicl, mass, fri, pH 8.0, g sm bdy
C3g	130-152	10YR 5/1 w/10YR 4/1 cts, f fi fa & f med 7.5YR 5/6 & 4/6 fe ox, sicl, mass, fri, pH 7.9

Soil: 71 (continued)

Notes: In the B3g horizon there is an accumulation of $CaCO_3$ nodules. The soil itself is not calcareous. The amount of calcium carbonate nodules increased in the C1ghorizon and the soil is weakly calcareous. Below 120 cm there is a further increase of $CaCO_3$ nodules. There are more 10YR 5/3 areas in the C2g horizon than there were in the C1g horizon.

Soil: 73
County: Page
Location: 396 m W & 37.5 m N of SE corner sec. 21, T70N, R36W
N. veg. (or crop): Soybeans
Physiography: Floodplain of the West Nodaway River
Gr. water: 102 cm

Horizon	Depth (cm)	Description
Ap	0-18	N 2/0, 10YR 2/1 dry, w/10YR 5/2 silty areas, sicl, wk fi gran & sbk, fri, pH 5.8, cl sm bdy
A12	18-36	N 2/0, 10YR 2/1 dry, sicl, wk fi gran, fri, pH 5.9, cl sm bdy
B1	36-64	10YR 2/1, 10YR 2/1-3/1 dry sicl, wk fi sbk, fri, pH 6.3, g sm bdy
B21	64-76	10YR 2/1, 10YR 2/1-3/1 dry sicl, wk fi sbk, fri, pH 6.5, g sm bdy
B22	76-104	10YR 2/1, 10YR 4/1-3/1 dry, hvy sicl, wk-mod fi sbk, fri, pH 6.8, g sm bdy
B23	104-123	10YR 3/1 w/10YR 2/1 cts, 10YR 3/1 dry, hvy sicl, mod fi sbk, fri, pH 6.7, g sm bdy
B3	123-142	10YR 3/1 w/10YR 2/1 cts, 10YR 3/1 dry, hvy sicl, wk fi sbk, fri, pH 7.0, cl sm bdy
C	142-152	10YR 3/1 w/10YR 2/1 cts, 10YR 3/1 dry, sicl, mass, fri, pH 6.9

Soil: 75
County: Plymouth
Location: 44 m N and 44 m W of SE corner of NW¼, NW¼ sec. 35, T92N, R43W
N. veg. (or crop): Pasture (bluegrass)
Physiography: Floodplain of Whiskey Creek
Gr. water: 94 cm

Horizon	Depth (cm)	Description
A11	0-15	10YR 3/2, 10YR 3/2 dry sicl, mod fi gran, fri, pH 6.0, abr sm bdy
A12	15-28	10YR 3/1, 10YR 2/1 dry, sicl, wk fi gran, fri, pH 6.2, cl sm bdy
A13	28-38	10YR 2/1, 10YR 2/1 dry, sicl, wk fi gran, fri, pH 6.4, cl sm bdy
B1	38-48	10YR 2/1, 10YR 2/1 dry, sicl, wk fi gran, fri, pH 6.5, cl sm bdy
B21	48-61	10YR 2/1, 10YR 3/1 dry, sicl, wk med sbk, fri, pH 6.6, cl sm bdy
B22	61-94	10YR 3/1, 10YR 3/1 dry, sicl, wk med prism → wk med sbk, fri, pH 6.8, cl sm bdy
BC	94-123	10YR 3/1, 10YR 4/1-4/2 dry, sicl, wk med sbk & mass, fri, pH 7.0, cl sm bdy
Cg	123-152	10YR 4/1, 10YR 5/1-5/2 dry, 2.5YR 2/2 Mn ox, sicl, mass, fri, pH 7.2

Soil: 79
County: Poweshiek
Location: 1584 m W & 790 m S of NE corner of sec. 36, T79N, R16W
N. veg. (or crop): Pasture
Physiography: Floodplain of Buffalo Creek
G. water: >178 cm

Horizon	Depth (cm)	Description
Ap	0-18	10YR 2/1, 10YR 2/1-3/1 dry, lgt sicl, wk & mod fi & med sbk, fri, pH 5.8, cl sm bdy
A12	18-38	N 2/0, 10YR 2/1-3/1 dry, lgt sicl, wk fi gran, fri, pH 5.9, g sm bdy
A13	38-52	N 2/0, 10YR 3/1-4/1 dry, sicl, wk fi prism → wk fi gran, fri, pH 6.4, g sm bdy
B1	52-66	N 2/0, 10YR 3/1-4/1 dry, sicl, wk fi prism → wk fi gran, fri, pH 6.5, g sm bdy
B21	66-87	10YR 3/1, 10YR 4/1 dry, sicl, mod med prism → wk fi & med sbk, fri, pH 6.5, g sm bdy
B22g	87-119	10YR 3/1-4/1, 10YR 4/1 dry, f fi fa 7.5YR 5/4 fe ox, lgt sicl, mod co prism → wk med sbk, fri, pH 6.7, g sm bdy
IIC1g	119-152	10YR 4/1, c fi p 7.5YR 4/4 fe ox, lgt sicl, mass, fri, pH 6.5, g sm bdy
IIC2g	152-165	10YR 5/1, mod med p 7.5YR 5/6 & c med d 10YR 6/1 mottles, lgt cl, mass, fri, pH 6.5, g sm bdy
IIC3g	165-178	7.5YR 5/6 & 10YR 6/1, hvy l, mass, fir, pH 6.5

Soil: 81
County: Sac
Location: SE corner of SE¼ NW¼ sec. 33, T88N, R37W
N. veg. (or crop): Corn
Physiography: Floodplain of Boyer River
Gr. water: >152 cm

Horizon	Depth (cm)	Description
Ap	0-18	10YR 2/1, 10YR 3/1 dry, lgt sicl, wk fi gran & wk med sbk, fri, pH 6.9, abr sm bdy
A12	18-41	10YR 2/1, 10YR 3/1 dry, sicl, wk vfi & fi gran, fri, pH 6.9, cl sm bdy
A13	41-51	10YR 2/1, 10YR 3/1 dry, sicl, wk fi gran & mod fi sbk, fri, pH 6.5, cl sm bdy
B1	51-61	10YR 2/1, 10YR 3/1 dry, sicl, wk fi gran & mod fi sbk, fri, pH 6.5, cl sm bdy
B21	61-76	N 2/0, 10YR 3/1 dry, sicl, wk fi gran → mod fi sbk, fri, pH 6.4, cl sm bdy
B22	76-91	N 2/0, 10YR 3/1 dry, sicl, wk fi prism → mod fi sbk, fri, pH 6.5, cl sm bdy
B23	91-122	N 2/0, 10YR 3/1, hvy sicl, mod med prism → mod med sbk, fri, pH 6.5, cl sm bdy
B24	122-152	10YR 3/1, 10YR 3/1-4/1 dry, hvy sicl, mod med prism → mod med sbk, fri, pH 6.6, cl sm bdy

Soil: 86
County: Tama
Location: 88 m N & 240 m W of NE¼ sec. 12, T85N, R15W
N. veg. (or crop): Corn
Physiography: Floodplain of Wolf and Four Mile Creek
Gr. water: >152 cm

Horizon	Depth (cm)	Description
Ap	0-20	N 2/0, 10YR 3/1-2/1 dry, sicl, wk fi gran & sbk, fri, pH 5.7, cl sm bdy
A12	20-36	N 2/0, 10YR 3/1-2/1 dry, sicl, wk med sbk → mod fi gran, fri, pH 5.7, cl sm bdy
A13	36-58	N 2/0, 10YR 3/1-2/1 dry, sicl, wk fi prism → wk fi gran, fri, pH 5.7, cl sm bdy
A14	58-84	10YR 2/1, 10YR 4/1-3/1 dry, sicl, mod med prism → mod med sbk, fri, pH 5.9, cl sm bdy
B21	84-99	10YR 3/1, 10YR 4/1 dry, sicl, mod med prism → wk med sbk, fri, pH 6.0, cl sm bdy
B22	99-114	10YR 3/1, 10YR 4/1 & 5/1 dry, lgt sicl, mod med prism → wk med sbk, fri, pH 6.0, cl sm bdy
B3g	114-130	10YR 4/1, 10YR 4/1 & 5/1 dry, lgt sicl, mod co prism → mod med sbk, fri, pH 6.0, cl sm bdy
Cg	130-152	10YR 4/1, 10YR 5/1 dry, f fi fa 7.5YR 5/4 mottles, hvy sil, mod co prism → wk med sbk, fri, pH 6.0

Soil: 88
County: Union
Location: 63 m E & 30 m S NW corner, sec. 2, T73N, R29W
N. veg. (or crop): Soybeans
Physiography: Floodplain of the Thompson Branch of the Grand River
Gr. water: >152 cm

Horizon	Depth (cm)	Description
Ap	0-20	10YR 2/1, 10YR 2/2 dry, lgt sicl, clod → wk fi sbk, fri, pH 6.1, abr sm bdy
A12	20-46	10YR 2/1, 10YR 3/2 dry, hvy sicl, mod fi gran, fri, pH 5.8, cl sm bdy
A13	46-69	10YR 2/1, 10YR 3/2 dry hvy sicl, wk med sbk, fri, pH 5.7, cl sm bdy
A14	69-91	10YR 2/1, 10YR 3/1-4/1 dry, hvy sicl, wk med & co sbk, fri, pH 5.7, cl sm bdy
A15	91-107	10YR 3/1, 10YR 4/1 dry, f fi fa 7.5YR 4/6 fe ox, hvy sicl, wk med & co sbk, fri, pH 5.8, cl sm bdy
B2	107-123	10YR 3/1, 10YR 4/1 dry, f fi fa 7.5YR 4/6 fe ox, hvy sicl, wk co & med sbk, fri, pH 5.9, cl sm bdy
B3	123-137	10YR 3/1, 10YR 4/2 dry, f fi fa 7.5YR 4/6 fe ox, hvy sicl, wk co sbk, fri, pH 5.9, cl sm bdy
Cg	137-152	10YR 5/2 & 4/1, 10YR 5/2 dry, f fi fa 7.5YR 4/4 fe ox, f 5YR 2/1 Mn ox, hvy sicl, mass, fri, pH 6.0

Soil: 95
County: Winnebago
Location: 47 m N & 23 m E NE corner of SE¼ SE¼ sec. 11, T98N, R24W
N. veg. (or crop): Permanent pasture
Physiography: Floodplain of the Winnebago River
Gr. water: >152 cm

Horizon	Depth (cm)	Description
A11	0-15	N 2/0, 10YR 2/1 dry, hvy sicl, mod fi gran, fri, pH 7.2, g sm bdy
A12	15-66	N 2/0, 10YR 3/1 dry, sicl, wk fi gran, fri, pH 7.1, cl sm bdy
A13	66-102	10YR 2/1 w/N 2/0 cts, 10YR 3/1-2/1, dry f fi fa 7.5YR 4/6 fe ox, sicl, wk fi sbk, fri, pH 7.0, cl sm bdy
A14	102-119	10YR 3/1 w/10YR 2/1 cts, 10YR 2/1 knd, 10YR 3/1 dry, 7.5YR 4/6 fe ox, sicl, wk f sbk, fri, pH 7.0, cl sm bdy
C	119-152	10YR 3/1, 10YR 3/1 dry w/c f & med d 7.5YR 4/4 fe ox, l, mass, fri, pH 7.2

Note: This profile was sampled every 5 cm to 112 cm.

Soil: 96-1
County: Winneshiek
Location: 19 m N & 131 m W of SE¼ SE¼ of sec. 7, T98N, R9W
N. veg. (or crop): Permanent pasture
Physiography: Floodplain of Ten Mile Creek
Gr. water: 123 cm

Horizon	Depth (cm)	Description
A11	0-20	10YR 2/1, hvy sil, wk vfi & fi gran, fri, pH 7.5, abr sm bdy
A12	20-36	10YR 2/1 w/N 2/0 cts, lgt sicl, wk fi gran, fri, pH 7.5, g sm bdy
A13	36-48	10YR 2/1, w/N 2/0 cts, lgt sicl, wk vfi & fi gran, fri, pH 7.3, g sm bdy
A14	48-66	10YR 2/1, lgt sicl, wk fi gran & sbk fri, pH 7.2, g sm bdy
A15	66-86	10YR 2/1, lgt sicl, wk med sbk, fri, pH 7.4, g sm bdy
A16	86-99	10YR 2/1, lgt sicl, wk fi prism → wk med sbk, fri, pH 7.3, g sm bdy
AC	99-112	10YR 2/1 w/10YR 3/1 in lower part, lgt sicl, v wk fi prism → mass, fri, pH 7.5, cl sm bdy
C1	112-130	10YR 3/1 w/10 YR 2/1 cts, lgt sicl, mass, fri, pH 7.1, g sm bdy
C2	130-152	10YR 3/1 w/10YR 2/1 cts, lgt sicl, mass, fri, pH 6.6

Notes: Areas close to sample site have a sandy loam texture at approximately 127 cm. Depth and thickness of sand are extremely variable. The field itself is very variable, hummocky topography (old stream channels).

Soil: 96-2
County: Winneshiek
Location: 19 m N & 48 m E of SW¼ SE¼ sec. 3, T97N, R9W
N. veg. (or crop): Soybeans (corn residue)
Physiography: Floodplain (unnamed creek)
Gr. water: 97 cm

Horizon	Depth (cm)	Description
Ap	0-18	N 2/0, hvy sicl, wk fi gran, fri, pH 7.4, abr sm bdy
A12	18-30	N 2/0, hvy sicl, wk fi gran, fri, pH 7.3, g sm bdy
A13	30-51	10YR 2/1 w/N 2/0 cts, lgt sic, mod fi gran, fri, pH 7.2, g sm bdy
A14	51-69	10YR 2/1 w/N 2/0 cts, hvy sicl, mod vfi & fi gran, fri, pH 7.0 g sm bdy
A15	69-91	10YR 2/1, hvy sicl, wk fi sbk, fri, pH 7.0, g sm bdy
A16	91-104	10YR 2/1, sicl, wk med sbk, fri, pH 6.7, g sm bdy
A17	104-130	10YR 2/1, sicl, wk med prism → wk med sbk, fri, pH 6.7, g sm bdy
C	130-152	10YR 3/1 w/10YR 2/1 cts, sicl, mass, fri, pH 6.8

Notes: Gravel at approximately 152 cm, but texture is a sicl.

Soil: 97
County: Woodbury
Location: 104 m N & 41 m E of the SE field corner SW¼, sec. 16, T89N, R44W
N. veg. (or crop): Corn
Physiography: Floodplain
Gr. water: 107 cm

Horizon	Depth (cm)	Description
Ap	0-20	10YR 3/1, 10YR 3/2 dry, 10YR 3/2 knd, 10YR 3/3 silty areas, sicl, clod → wk med sbk, fri, pH 5.6, abr sm bdy
A12	20-36	10YR 2/1, 10YR 3/1 dry,hvy sicl, wk fi & med sbk, fri, pH 6.2, cl sm bdy
A13	36-51	10YR 2/1, 10YR 3/1 dry,sicl, wk med sbk, fri, pH 6.4, cl sm bdy
A14	51-71	10YR 2/1, 10YR 3/1-4/1 dry,sicl, wk med sbk, fri, pH 6.7, cl sm bdy
A15	71-91	10YR 2/1, 10YR 3/1-4/1 dry,hvy sicl, wk med sbk, fri, pH 6.7, cl sm bdy
A16	91-123	10YR 2/1, 10YR 3/1-4/1 dry, sicl, wk med sbk, fri, pH 6.7, cl sm bdy
AC	123-140	10YR 3/1, 10YR 4/1 dry, sicl, wk med sbk & mass, fri, pH 6.6, cl sm bdy
C	140-152	10YR 3/1, 10YR 4/1 dry, sicl, mass, fri, pH 6.5

Soil: N1
County: Stanton (Nebraska)
Location: 46 m W & 45 m W of the SW corner of SE¼ sec. 2, T21N, R3E
N. veg. (or crop): Red clover
Physiography: Floodplain of the East Maple Creek
Gr. water: 145 cm

Horizon	Depth (cm)	Description
Ap	0-18	10YR 4/3 ex & 10YR 3/2 in, 10YR 3/2 knd, hvy sicl, wk fi gran, fri, pH 6.8, abr sm bdy
A12	18-33	10YR 4/3 ex & 10YR 3/2 in, 10YR 3/2 knd, 10YR 4/2 dry, w/10YR 5/3 silty areas, hvy sicl, wk fi gran & sbk, fri, pH 6.5, cl sm bdy
A13	33-56	N 2/0 w/areas of 10YR 3/2, 10YR 3/1 dry, sicl, wk fi & med sbk, fri, pH 6.7, cl sm bdy
A14	56-66	10YR 2/1, 10YR 3/1 dry sicl, wk fi & med sbk, fri, pH 7.2, g sm bdy
A15	66-79	10YR 2/1, 10YR 3/1-4/1 dry sicl, wk fi & med sbk, fri, pH 7.4, g sm bdy
B1	79-97	10YR 2/1, 10YR 3/1-4/1 dry, sicl, wk med sbk, fri, pH 7.5, g sm bdy
B2	97-109	10YR 3/1, 10YR 4/1 dry, sicl, wk fi & med sbk, fri, pH 7.4, g sm bdy
BC	109-123	10YR 3/1 w/10YR 4/1, 10YR 4/1 & 5/1 dry w/f fi fa 7.5YR 4/6 fe ox, sicl, wk med sbk → mass, fri, pH 7.6, g sm bdy
Cg	123-152	10YR 4/1, 10YR 5/2 dry w/f fi fa 7.5 YR 4/6 fe ox, sicl, mass, fri, pH 7.5

Notes: Bored approximately 25 holes on the north and south side of gravel road. Closer to the stream the soil is calcareous. Overwash is generally thick in the area but the thickness varies. Stream floods every year.

Soil: N2
County: Cuming (Nebraska)
Location: 76 m S & 45 m E of the NW corner of the NW¼ sec. 32, T22N, R5E
N. veg. (or crop): Corn
Physiography: Floodplain of Pebble Creek
Gr. water: >152 cm

Horizon	Depth (cm)	Description
Ap	0-18	10YR 2/1 w/10YR 4/2 silty areas, 10YR 3/2 knd, 10YR 4/1 dry, sicl, wk fi & med gran, fri, pH 6.0, abr sm bdy
A12	18-28	10YR 2/1, 10YR 3/1-4/1 dry, sicl, wk fi gran, fri, pH 5.7, g sm bdy
A13	28-48	10YR 2/1, 10YR 3/1-4/1 dry, lgt sicl, wk fi & med sbk, fri, pH 5.7, g sm bdy
A14	48-79	10YR 2/1, 10YR 3/1-4/1 dry w/f fi fa 5YR 4/4 fe ox, lgt sicl, wk fi & med sbk, fri, pH 5.9, g sm bdy
A15	79-109	10YR 3/1, 10YR 3/1-4/1 dry, f fi fa 5YR 3/3 fe ox, lgt sicl, mod med prism → wk fi & med sbk, fri, pH 6.4, g sm bdy
A16	109-132	10YR 3/1 w/c med d 5YR 3/3 fe ox, lgt sicl, wk co prism → wk fi & med sbk, fri, pH 6.8, g sm bdy
A17	132-152	10YR 3/1 3/10YR 4/1 in lower part of horizon, c med d 5YR 3/3 fe ox, lgt sicl, wk med sbk, fri, pH 6.9

Soil: N3
County: Washington (Nebraska)
Location: 50 m E & .50 km N of the SW corner of the SW¼
sec. 19, T18N, R10E
N. veg. (or crop): Corn
Physiography: Floodplain of the Little Bell Creek
Gr. water: >152 cm

Horizon	Depth (cm)	Description
Ap	0-18	10YR 2/2 ex, 10YR 2/1 in, 10YR 2/2 knd, 10YR 4/1 dry, sicl, clod → wk fi gran & mod med sbk, fri, pH 5.7, abr sm bdy
A12	18-48	N 2/0, 10YR 2/1 dry, hvy sicl, wk med prism → mod med sbk, fri, pH 6.3, g sm bdy
A13	48-94	10YR 3/1, 10YR 4/1 dry, hvy sicl, wk med prism → wk med & co sbk, fri, pH 6.6, g sm bdy
B	94-140	10YR 3/1, lower part grades to 10YR 4/1, 10YR 4/1 dry, f 5YR 2/1 Mn conc, f fi fa 7.5YR 4/6 mottles, hvy sicl, wk co prism, mass, fri, pH 6.7, g sm bdy
Cg	140-152	10YR 4/1 & 3/1, 10YR 4/1 dry, f fi fa 7.5YR 4/6 & 10YR 5/2 mottles, hvy sicl, mass, fri, pH 6.7

Soil: N4
County: Saunders (Nebraska)
Location: 86 m E & 43 m N of SW corner of the SE¼ of the SE¼ sec. 11, T14N, R7E
N. veg. (or crop): Corn
Physiography: Floodplain of Sand Creek (tributary of Wahoo Creek)
Gr. water: 122 cm

Horizon	Depth (cm)	Description
Ap	0-18	10YR 3/1 w/10YR 4/2 silty areas, 10YR 2/2 knd, 10YR 4/2 dry, lgt sicl, wk med sbk, fri, pH 6.0, abr sm bdy
A12	18-25	10YR 2/1 w/10YR 4/2 silty areas, 10YR 4/1 dry, lgt sicl, wk fi & med gran & wk med sbk, fri, pH 6.1, abr sm bdy
B1	25-38	N 2/0 w/10YR 5/2 silty areas, 10YR 3/1-4/1, sicl, wk fi & med sbk, fri, pH 5.7, g sm bdy
B21	38-71	N 2/0, 10YR 3/1 dry, sicl, mod med prism → mod fi & med sbk, fri, pH 5.7, cl sm bdy
B22	71-89	10YR 2/1 & 10YR 3/1, 10YR 3/1-4/1 dry, sicl, mod med prism → mod fi & med sbk, fri, pH 5.9, g sm bdy
B3g	89-112	10YR 3/1 & 10YR 4/1 w/10 YR 7/2 silty areas, 10YR 4/1-5/1 dry, f fi fa 7.5YR 4/4, sicl, wk med sbk & mass, fri, pH 6.2, g sm bdy
C1g	112-127	2.5Y 5/2 & 10YR 4/1, 10YR 5/2 dry, f fi fa 7.5YR 6/2 & 4/4 mottles, sicl, mass, fri, pH 6.4, g sm bdy
C2g	127-152	2.5Y 5/2 & 10YR 4/1, 10YR 5/2 dry, f fi fa 10YR 5/1, c co p 7.5YR 4/6 mottles, sil, mass, fri, pH 6.5

Soil: M1
County: Harrison (Missouri)
Location: 76 m N & 82.5 m E of SW field corner, sec. 12, T63N, R26W
N. veg. (or crop): Corn
Physiography: Floodplain of the Thompson River
Gr. water: 84 cm

Horizon	Depth (cm)	Description
Ap	0-18	10YR 2/1, 10YR 3/1 dry, lgt sicl, wk fi gran, fri, pH 6.5, cl sm bdy
A12	18-33	10YR 2/1, 10YR 3/1 dry, lgt sicl, wk fi sbk, fri, pH 6.7, cl sm bdy
A3	33-43	10YR 2/1, 10YR 3/1 dry, lgt sicl, wk fi prism → wk fi sbk, fri, pH 6.5, cl sm bdy
B21	43-69	10YR 2/1, 10YR 3/1 dry, lgt sicl, mod fi prism → mod fi sbk, fri, pH 6.4, cl sm bdy
B22	69-86	10YR 2/1-3/1, 10YR 3/1 dry, f fi fa 7.5YR 4/6 mottles, lgt sicl, wk fi & med sbk, fri, pH 6.5, g sm bdy
B23	86-97	10YR 3/1, 10YR 4/1 dry, c fi fa 7.5YR 3/4 mottles, lgt sicl, wk med sbk, fri, pH 6.4, g sm bdy
B3	97-107	10YR 3/1, 10YR 4/1-4/2 dry, c fi fa 7.5YR 3/4 mottles, lgt cl, wk med, fri, pH 6.4, g sm bdy
C1	107-127	10YR 3/1, 10YR 4/1-4/2 dry, c fi fa 7.5YR 3/4 mottles, lgt cl, mass, fri, pH 6.5, g sm bdy
C2g	127-140	10YR 3/1 & 4/1, 10YR 4/1-4/2 dry, c fi fa & f med 7.5YR 3/4 mottles, l, mass, fri, pH 6.5, g sm bdy
C3g	140-152	10YR 4/1, 10YR 4/1-4/2 dry, c m 7.5YR 3/4 mottles, l, mass, fri, pH 6.5

Soil: M2
County: Lafayette (Missouri)
Location: 233 m E & 33 m N of private road in the SW¼ of sec. 1, T48N, R26W
N. veg. (or crop): Corn
Physiography: Floodplain of Davis Creek & North Blackjack
Gr. water: 104 cm

Horizon	Depth (cm)	Description
Ap	0-10	10YR 3/1, 10YR 4/1 dry, sicl, wk med sbk, fri, pH 5.6, abr sm bdy
A12	10-20	10YR 2/1, 10YR 4/1 dry, sicl, wk fi prism → wk fi & med sbk, fri, pH 5.6, cl sm bdy
B21	20-33	10YR 2/1, 10YR 4/1 dry, lgt sic, mod med prism → mod fi & med sbk, fri, pH 5.5, cl sm bdy
B22	33-43	10YR 2/1, 10YR 4/1 dry, f fi fa 5YR 3/3 fe ox, hvy sicl, mod med prism → mod med sbk, fri, pH 5.7, cl sm bdy
B23	43-61	10YR 3/1, 10YR 4/1 dry, hvy sicl, mod med prism → mod med sbk, fri, pH 5.9, cl sm bdy
B24	61-102	10YR 3/1, 10YR 4/1 dry, f c p 5YR 3/3 fe ox, sicl, w/f med prism → wk med sbk, fri, pH 5.8, cl sm bdy
B31g	102-123	10YR 4/1, 10YR 4/1 dry, f fi fa 7.5YR 4/4 mottles, sicl, mod fi prism → wk med sbk, fri, pH 5.8, cl sm bdy
B32g	123-135	10YR 4/1, 10YR 4/1 dry f fi fa 5YR 3/3 mottles, lgt sicl, mod fi prism → wk med sbk, fri, pH 6.2, cl sm bdy
B33g	135-152	10YR 4/1, 10YR 5/1 dry, c fi fa 7.5YR 4/4 mottles, sicl, mod fi prism → wk med sbk, fri, pH 6.4

Soil: M3
County: Caldwell (Missouri)
Location: 198 m N, 198 m E of SW¼ SW¼ sec. 11, T56N, R27W
N. veg. (or crop): Unharvested soybeans
Physiography: Floodplain (Shoal, Cottonwood, Little Otter Creeks, about 1/2 mile from Otter & Shoal Crek Creeks)
Gr. water: >152 cm

Horizon	Depth (cm)	Description
Ap	0-18	10YR 2/1, 10YR 4/2 dry, sil, clod → wk fi sbk, fri, pH 6.8, cl sm bdy
A12	18-33	10YR 2/1, 10YR 3/1 dry, lgt sicl, mod fi & med sbk, fri, pH 7.0, g sm bdy
B1	33-46	10YR 2/1, 10YR 4/1 dry lgt sicl, mod med sbk, fri, pH 6.4, cl sm bdy
B21	46-61	10YR 2/1, 10YR 4/1 dry, sicl, mod med sbk, fri, pH 6.0, g sm bdy
B22	61-86	10YR 2/1, 10YR 4/1 dry, hvy sicl, mod fi & v fi sbk, fri, pH 6.0, g sm bdy
B23	86-122	10YR 3/1, 10YR 4/1 dry, hvy sicl, mod med prism → mod med sbk, fri, pH 6.1, g sm bdy
B3g	122-152	10YR 4/1, 10YR 4/1-5/1 dry, f fi fa 10YR 4/2 & 7.5YR 4/4, hvy sicl, mod med prism → wk fi sbk, fri, pH 6.5

Soil: M4
County: Scotland (Missouri)
Location: 11 m E of Route U and 14 m S of row of trees on west edge of SW¼ NE¼ sec. 1, T64N, R11#
N. veg. (or crop): Corn
Physiography: Floodplain of the North Fabius River
Gr. water: 102 cm

Horizon	Depth (cm)	Description
Ap	0-20	10YR 2/1, 10YR 3/2 dry, 10YR 2/2 knd, sicl, clod → wk fi sbk, fri, pH 6.8, cl sm bdy
A12	20-36	10YR 2/1, 10YR 3/2 & 3/1 dry, sicl, wk fi prism → wk fi & med sbk, fri, pH 6.7, cl sm bdy
B21	36-66	N 2/0, 10YR 3/1 dry, f fi fa 7.5YR 3/4 mottles, hvy sicl, wk med sbk, fri, pH 5.8, cl sm bdy
B22	66-91	N 2/0, 10YR 3/1-4/1 dry, f med d 7.5YR 3/4 mottles, sicl, mod med prism → wk med sbk, fri, pH 5.9, cl sm bdy
B23	91-102	7.5YR 3/0 & 10YR 4/1, 10YR 4/1 & 5/1 dry, c med d 7.5YR 3/4 mottles, sicl, mod med prism → mod med sbk, fri, pH 5.9, cl sm bdy
B24	102-123	7.5YR 3/0 & N 2/0, 10YR 4/1 & 5/1 dry, c med d 7.5YR 3/4 mottles, hvy sicl, mod med sbk, fri, pH 6.0, cl sm bdy
B25	123-137	7.5YR 3/0, 10YR 5/1 dry, c med d 7.5YR 3/4 mottles, hvy sicl, str co prism → mod med sbk, fri, pH 6.2, cl sm bdy
B3	137-152	10YR 4/1, 10YR 5/1 dry, c med d 7.5YR mottles, hvy sicl, wk med sbk, fri-fir, wk med, pH 6.3

Soil: I
County: Logan (Illinois)
Location: 890 m S & 790 m E of NW corner of the NW¼ of NE¼ sec. 7, T19N, R3W
N. veg. (or crop): Pasture - mostly grasses
Physiography: Floodplain of Deer Creek
Gr. water: 1 meter

Horizon	Depth (cm)	Description
Ap	0-18	10YR 2/1, 10YR 4/2 dry, 10YR 2/2 knd, 10YR 7/2 silty areas, lgt sicl, wk fi gran, fri, pH 6.4, abr sm bdy
A12	18-30	10YR 2/1, 10YR 3/1 dry, sicl, mod fi gran, fri, pH 6.8, cl sm bdy
B21	30-58	10YR 2/1, 10YR 3/1 dry, sicl, wk med fi & med sbk, fri, pH 6.9, cl sm bdy
B22	58-79	10YR 2/1, 10YR 3/1 dry,lgt cl, mod med sbk, fri, pH 6.9, cl sm bdy
B31	79-97	10YR 2/1-3/1, 10YR 3/1 dry, lgt cl, wk med sbk, fri, pH 6.8, cl sm bdy
B32g	97-122	10YR 3/1-4/1 f fi p 10YR 6/6, lgt cl, wk med sbk, fri, pH 6.8

Soil: I2
County: Champaign (Illinois)
Location: 43.5 m W of Cul-De-Sac gravel road, 30 m S & 135 m N of SW corner sec. 1, T20N, R7E
N. veg. (or crop):
Physiography: Floodplain of the Sangamon River
Gr. water: 127 cm

Horizon	Depth (cm)	Description
A11	0-23	10YR 3/1, 10YR 5/2 dry, lgt sicl, wk thin pl, fri, pH 7.0, cl sm bdy
A12	23-58	10YR 2/1, 10YR 5/1 dry, f fi p 7.5YR 4/6 mottles, lgt sicl, wk med sbk → mod med gran, fri, pH 6.8, cl sm bdy
A13	58-97	10YR 3/1, 7.5YR 4/6 mottles, lgt sicl, mod fi & med ang & sbk, fri, pH 6.5, cl sm bdy
B2	97-127	10YR 3/1, c f p 5Y 5/3 & f co p 7.5YR 4/6 mottles, lgt sicl, wk med prism → mod med sbk, fri, pH 6.6, cl sm bdy
Cg	127-173	5Y 5/1 & 2.5Y 4/2, m co d 7.5YR 4/6 & c co d 10YR 4/4 mottles, c fi Fe-Mn accum, lgt sicl, mass, fri, pH 6.6

Soil: MINN1
County: Waseca (Minnesota)
Location: 20 m directly E of tree near center of SE¼ of sec. 25, T107N, R24W
N. veg. (or crop): Corn
Physiography: Floodplain of the LeSueur River
G. water: 71 cm

Horizon	Depth (cm)	Description
Ap	0-15	N 2/0, 10YR 4/1, 5/1, 5/2 dry, sic, clod → wk med sbk, fri, pH 7.3, cl sm bdy
A12	15-28	N 2/0, 10YR 2/1 & 3/1 dry, sic, wk med sbk, fri, pH 7.3, cl sm bdy
A13	28-46	N 2/0, 10YR 3/1 dry, sic, fi mod & med sbk, fri, pH 7.1, cl sm bdy
A14	46-76	N 2/0, 10YR 3/1, 10YR 4/1 dry, sic, mod fi gran, fri, pH 7.0, cl sm bdy
A15	76-94	N 2/0, 10YR 4/1 dry, f 10YR 3/1 cts, sic, mod fi gran, fri, pH 6.8, cl sm bdy
A16	94-114	10YR 2/1, 10YR 4/1 dry, sic, wk fi gran & sbk, fri, pH 6.9, cl sm bdy
A17	114-127	10YR 2/1, 10YR 4/1 dry, sic, wk fi sbk, fri, pH 6.9, cl sm bdy
C1	127-140	10YR 2/1, 10YR 4/1 & 5/1 dry, sic, mass, fri, pH 6.8, cl sm bdy
C2	140-152	10YR 2/1, 10YR 4/1 & 5/1 dry, f fi fa 7.5YR 4/4 & 5/6 & 10YR 5/3 mottles, sic, mass, fri, pH 6.8

Soil: MINN2
County: Dakota Co., Minnesota
Location: 29 m S & 23 m W of NE corner of SW¼ sec. 3, T112W, R20W
N. veg. (or crop): Tall grasses
Physiography: Floodplain of Chub Creek
Gr. water: 51 cm

Horizon	Depth (cm)	Description
A11	0-15	10YR 2/1, 10YR 3/1 dry, 7.5YR & 10YR 5/2 silty areas, lgt sicl, wk fi gran, fri, pH 6.6, cl sm bdy
A12	15-38	10YR 2/1, 10YR 3/1 & 2/1 dry, vf fi fa 5YR 5/2 mottles, lgt sicl, wk fi sbk, fri, pH 6.8, cl sm bdy
A13	38-61	10YR 2/1, 10YR 3/1 dry, vf fi fa 5YR 5/2 mottles, l, wk co sbk, fri, pH 6.9, cl sm bdy
A14	61-76	10YR 2/1, 10YR 3/1 dry, vf fi fa 5YR 5/2, l, wk co sbk, fri, pH 6.9, cl sm bdy
A15	76-91	10YR 2/1, 10YR 4/1 dry, vf fi fa 5YR 5/2 mottles, hvy sil, wk co sbk, fri, pH 6.9, cl sm bdy
Cg	91-122	Mottled 2.5Y 5/2 & 10YR 5/6 & 6/2 2.5Y 6/2 & 7/2 dry, vf fi fa 5YR 2/ Mn ox, sil, mass, fri, pH 7.2

APPENDIX B: LABORATORY ANALYSES

Glossary of Terms Used to Identify Laboratory Analyses

The following is a list of abbreviations used in the laboratory analyses tables.

SOIL	First number is the county in which the soil profile was sampled. The second number indicates the horizon in the profile. A letter indicates the horizon was subsampled. Exceptions are N for Nebraska, MINN for Minnesota, M for Missouri and I and I2 for Illinois
HORIZON	Standard horizon nomenclature defined in Soil Taxonomy (Soil Survey Staff, 1951). An exception is a number 2 before the letter. The number 2 indicates a lithologic discontinuity as does the Roman numeral two.
DEPTH CM	Depth in centimeters
MDPT CM	Midpoint in centimeters
WGTPT	Horizon thickness used in calculating the weighted value.
PH	pH in pH units
SAND, SILT, CLAY	Particle-size analysis in percent.
TC	Total carbon in percent
AVP	Available phosphorus in ppm
TP	Total phosphorus in ppm
IP	Inorganic phosphorus in ppm
OP	Organic phosphorus in ppm
OC/OP	Ratio of organic carbon to organic phosphorus
OP/TP	Ratio of organic phosphorus to total phosphorus x 100

HION	Hydrogen ion activity in moles/liter

Soil Testing Laboratory Analyses

STPH	pH in pH units
STBPH	Buffer pH in pH units
STAVP	Available phosphorus in ppm
STAVK	Available potassium in ppm
STHION	Hydrogen ion activity in moles/liter
STBHION	Buffer hydrogen with activity in moles/ liter
*	Interpreted off graph

Soil 1

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
1-1	AP	0-18	9	18	5.8	3.0	63.5	33.5	2.6
1-2	A12	18-36	27	18	5.9	3.6	65.8	30.6	2.2
1-3A	A13	36-48	42	12	5.7	4.5	65.3	30.2	1.5
1-3B	A13	48-61	55	13	5.7	4.6	61.9	33.5	1.1
1-4A	B1	61-74	68	13	5.7	4.6	55.5	39.9	0.9
1-4B	B1	74-84	79	10	5.7	5.4	54.3	40.3	0.9
1-5	B21	84-102	93	18	5.6	6.2	52.7	41.1	0.7
1-6	B22	102-117	110	15	5.8	6.4	50.4	43.2	.
1-7	B3	117-137	127	20	5.7	6.9	52.1	41.0	.
1-8	C	137-152	145	15	5.9	8.2	51.9	39.9	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
1-1	AP	0-18	32	739	438	301	86	41	0.0000016
1-2	A12	18-36	34*	784	263	521	42	66	0.0000013
1-3A	A13	36-48	36	665	463	202	74	30	0.000002
1-3B	A13	48-61	36*	594	238	356	31	60	0.000002
1-4A	B1	61-74	35	490	300	190	47	39	0.000002
1-4B	B1	74-84	42*	488	325	163	55	33	0.000002
1-5	B21	84-102	51	525	338	187	37	36	0.0000025
1-6	B22	102-117	53*	520	388	132	.	25	0.0000016
1-7	B3	117-137	55*	522	375	147	.	28	0.000002
1-8	C	137-152	57	541	388	153	.	28	0.0000013

Soil 1

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
1-1	AP	0-18	6.2	6.6	32	91	6.30000E-07	2.50000E-07
1-2	A12	18-36	6.2	6.6	26	27	6.30000E-07	2.50000E-07
1-3A	A13	36-48	6.1	6.7	26	30	7.90000E-07	2.00000E-07
1-3B	A13	48-61	6.1	6.6	24	25	7.90000E-07	2.50000E-07
1-4A	B1	61-74	6.1	6.8	18	13	7.90000E-07	1.60000E-07
1-4B	B1	74-84	5.8	7.0	21	13	0.0000013	1.00000E-07
1-5	B21	84-102	6.2	7.3	15	13	6.30000E-07	5.00000E-08
1-6	B22	102-117	6.1	7.1	30	16	7.90000E-07	7.90000E-08
1-7	B3	117-137	6.2	7.1	29	18	6.30000E-07	7.90000E-08
1-8	C	137-152	6.4	7.3	24	14	4.00000E-07	5.00000E-08

Soil 4

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
4-1	A11	0-13	7	13	7.0	12.9	60.8	26.3	2.5
4-2	A12	13-28	21	15	6.9	13.0	55.9	31.1	2.0
4-3	B21	28-43	36	15	6.1	11.8	53.9	34.3	1.6
4-4	B22	43-59	51	16	5.7	10.1	54.8	35.1	1.2
4-5A	B23	59-69	64	10	5.7	10.3	57.1	32.6	1.1
4-5B	B23	69-79	74	10	5.7	11.8	55.0	33.2	1.1
4-6	B3	79-94	87	15	5.7	13.2	55.7	31.1	0.9
4-7A	BCG	94-107	101	13	5.7	17.2	55.0	27.8	0.5
4-7B	BCG	107-119	113	12	5.8	22.6	51.1	26.3	.
4-7C	BCG	119-130	125	11	6.0	.	.	.	.
4-8	CG	130-152	141	22	6.0	23.3	51.8	24.9	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
4-1	A11	0-13	32	485	225	260	96	54	1.00000E-07
4-2	A12	13-28	9	375	125	250	80	67	1.30000E-07
4-3	B21	28-43	7	299	75	224	71	75	7.90000E-07
4-4	B22	43-59	5	225	63	162	74	72	0.000002
4-5A	B23	59-69	5	188	63	125	88	66	0.000002
4-5B	B23	69-79	7	207	75	132	83	64	0.000002
4-6	B3	79-94	7	214	113	101	89	47	0.000002
4-7A	BCG	94-107	6	225	125	100	50	44	0.000002
4-7B	BCG	107-119	7	243	150	93	.	38	0.0000016
4-7C	BCG	119-130	10	299	238	61	.	20	1.00000E-06
4-8	CG	130-152	12	353	263	90	.	25	1.00000E-06

Soil 5

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
5-1	AP	0-23	12	23	6.5	7.5	62.5	30.0	2.4
5-2	A12	23-48	36	25	5.5	8.1	58.0	33.9	1.8
5-3	A13	48-84	66	36	5.5	9.8	56.3	33.9	0.9
5-4	B	84-112	98	28	5.9	6.2	59.9	33.9	0.4
5-5	C1	112-132	122	20	5.8	6.8	59.8	33.4	0.3
5-6	C2	132-157	145	25	6.2	4.1	57.9	38.0	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
5-1	AP	0-23	73	776	550	226	106	29	3.20000E-07
5-2	A12	23-48	35	678	350	328	55	48	0.0000032
5-3	A13	48-84	30	449	325	124	73	28	0.0000032
5-4	B	84-112	41	563	500	63	11	11	0.0000013
5-5	C1	112-132	53	580	550	30	6	9	0.0000016
5-6	C2	132-157	58	603	550	53	.	9	6.30000E-07

Soil 6

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
6-1	AP	0-18	9	18	6.1	2.1	68.5	29.4	3.1
6-2	A12	18-33	26	15	6.0	3.1	65.9	31.0	3.3
6-3A	A13	33-46	40	13	5.8	6.6	59.2	34.2	3.9
6-3B	A13	46-61	54	15	5.9	6.5	58.7	34.8	2.7
6-4	B21	61-79	70	18	6.1	4.7	58.0	37.3	1.4
6-5	B22	79-91	85	12	6.2	4.8	59.1	36.1	0.8
6-6	B3G	91-102	97	11	6.2	4.0	63.1	32.9	0.6
6-7	AB	102-112	107	10	6.3	4.6	60.1	35.3	2.6
6-8A	C1G	112-117	114	5	6.3	5.5	65.1	29.4	0.3
6-8B	C1G	117-135	126	18	6.4	4.5	69.8	25.7	0.2
6-9	C2G	135-152	144	17	6.4	6.8	67.9	25.3	0.1

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
6-1	AP	0-18	46	881	350	531	58	60	7.90000E-07
6-2	A12	18-33	27*	713	300	413	80	58	1.00000E-06
6-3A	A13	33-46	8	656	175	481	81	73	0.0000016
6-3B	A13	46-61	8*	525	200	325	83	62	0.0000013
6-4	B21	61-79	8*	415	188	227	62	54	7.90000E-07
6-5	B22	79-91	8	450	200	250	32	56	6.30000E-07
6-6	B3G	91-102	11*	563	450	113	53	20	6.30000E-07
6-7	AB	102-112	14	743	562	181	144	24	6.30000E-07
6-8A	C1G	112-117	16*	731	600	131	23	.	6.30000E-07
6-8B	C1G	117-135	16	697	650	47	43	7	4.00000E-07
6-9	C2G	135-152	20	597	590	7	142	.	4.00000E-07

Soil 6

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
6-1	AP	0-18	6.3	6.8	52	91	5.00000E-07	1.60000E-07
6-2	A12	18-33	6.7	6.8	25	39	2.00000E-07	1.60000E-07
6-3A	A13	33-46	6.4	6.7	9	28	4.00000E-07	2.00000E-07
6-3B	A13	46-61	6.5	6.9	8	25	3.20000E-07	1.30000E-07
6-4	B21	61-79	6.6	7.1	6	23	2.50000E-07	7.90000E-08
6-5	B22	79-91	6.8	7.2	9	24	1.60000E-07	6.30000E-08
6-6	B3G	91-102	7.1	7.4	9	26	7.90000E-08	4.00000E-08
6-7	AB	102-112	7.1	7.3	12	27	7.90000E-08	5.00000E-08
6-8A	C1G	112-117	7.1	7.4	12	27	7.90000E-08	4.00000E-08
6-8B	C1G	117-135	.	.	.	.	.	.
6-9	C2G	135-152	.	.	.	.	.	.

Soil 16

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
16-1	AP	0-23	12	23	6.3	4.0	67.3	28.7	2.4
16-2	A12	23-43	33	20	6.0	8.2	62.5	29.3	2.1
16-3	A13	43-61	52	18	6.1	11.6	59.3	29.1	2.0
16-4	B2	61-71	66	10	6.3	10.3	63.4	26.3	0.5
16-5	B31G	71-84	78	13	6.4	11.7	63.1	25.2	0.3
16-6	B32G	84-104	94	20	6.5	17.1	62.7	20.2	0.2
16-7	CG	104-123	114	19	6.6	18.3	65.0	16.7	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	CP	OC/OP	OP/TP	HION
16-1	AP	0-23	27	746	362	384	63	51	5.00000E-07
16-2	A12	23-43	16*	522	225	297	71	57	1.00000E-06
16-3	A13	43-61	7	413	232	181	110	44	7.90000E-07
16-4	B2	61-71	6*	338	225	113	44	33	5.00000E-07
16-5	B31G	71-84	6	373	175	198	15	53	4.00000E-07
16-6	B32G	84-104	7*	394	313	81	25	21	3.20000E-07
16-7	CG	104-123	8	528	463	65	.	12	2.50000E-07

Soil 18

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
18-1A	AP	0-10	5	10	5.9	2.6	61.6	35.8	3.9
18-1B	AP	10-20	15	10	5.7	2.7	58.8	38.5	3.9
18-2A	A12	20-30	25	10	6.1	2.9	57.7	39.5	3.7
18-2B	A12	30-38	34	8	6.1	3.4	60.6	36.0	2.7
18-3	A13	38-48	43	10	6.2	4.3	59.4	36.3	2.3
18-4	A14	48-61	55	13	6.8	4.9	58.4	36.7	2.1
18-5	A15	61-76	69	15	7.2	6.0	57.1	36.9	1.2
18-6A	B21	76-89	83	13	7.6	6.5	58.9	34.6	1.0
18-6B	B21	89-102	95	13	7.5	6.6	59.0	34.4	0.9
18-7	B22	102-112	107	10	7.6	6.1	59.0	34.9	.
18-8A	B23	112-123	118	11	7.5	8.1	56.6	35.3	.
18-8B	B23	123-132	128	9	7.4	9.7	56.1	34.2	.
18-9A	CG	132-142	137	10	7.4	10.0	59.2	30.8	.
18-9B	CG	142-152	147	10	7.4	11.2	57.4	31.4	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	CP/TP	HION
18-1A	AP	0-10	35	684	325	359	109	52	0.0000013
18-1B	AP	10-20	33	665	325	340	115	51	0.000002
18-2A	A12	20-30	11	660	238	422	88	64	7.90000E-07
18-2B	A12	30-38	14	625	225	400	68	64	7.90000E-07
18-3	A13	38-48	8	483	175	308	75	64	6.30000E-07
18-4	A14	48-61	5	408	150	258	81	63	1.60000E-07
18-5	A15	61-76	3	319	138	181	66	57	6.30000E-08
18-6A	B21	76-89	3	262	150	112	89	43	2.50000E-08
18-6B	B21	89-102	4	267	175	92	98	34	2.50000E-08
18-7	B22	102-112	8	336	200	136	.	40	2.50000E-08
18-8A	B23	112-123	11	336	238	98	.	29	3.20000E-08
18-8B	B23	123-132	15	336	275	61	.	18	4.00000E-08
18-9A	CG	132-142	17	373	288	85	.	23	4.00000E-08
18-9B	CG	142-152	19	379	300	79	.	21	4.00000E-08

Soil 21

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
21-1	AP	0-15	8	15	5.7	8.5	54.4	37.1	3.3
21-2	A12	15-23	19	8	6.0	7.0	56.6	36.4	3.0
21-3	A13	23-38	31	15	6.5	8.2	55.8	36.0	2.0
21-4	A14	38-53	46	15	6.6	9.2	55.2	35.6	1.4
21-5	B21	53-61	57	8	6.8	10.3	56.1	33.6	1.0
21-6	B22	61-71	66	10	6.9	11.7	53.4	34.9	0.9
21-7A	B31	71-84	78	13	6.9	14.4	53.9	31.7	0.8
21-7B	B31	84-99	92	15	7.5	19.4	49.1	31.5	0.6
21-8	B32	99-109	104	10	7.7	21.4	49.3	29.3	1.2
21-9	C1G	109-127	118	16	7.8	26.3	44.8	28.9	1.5
21-10A	C2G	127-140	134	13	7.8	31.5	38.8	29.7	1.4
21-10B	C2G	140-150	145	10	7.6	.	.	.	1.3
21-11A	C3G	150-160	155	10	7.8	.	.	.	.
21-11B	C3G	160-170	165	10	7.8	51.8	28.5	19.7	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
21-1	AP	0-15	37	609	275	334	99	55	0.000002
21-2	A12	15-23	19	501	200	301	100	60	1.00000E-06
21-3	A13	23-38	6	417	188	229	87	55	3.20000E-07
21-4	A14	38-53	5	378	200	178	79	47	2.50000E-07
21-5	B21	53-61	3	319	188	131	76	41	1.60000E-07
21-6	B22	61-71	7	324	200	124	73	38	1.30000E-07
21-7A	B31	71-84	5	359	238	121	66	34	1.30000E-07
21-7B	B31	84-99	4	557	338	219	27	39	3.20000E-08
21-8	B32	99-109	2	606	400	206	58	34	2.00000E-08
21-9	C1G	109-127	5	610	450	160	93	26	1.60000E-08
21-10A	C2G	127-140	0	620	463	157	89	25	1.60000E-08
21-10B	C2G	140-150	0	644	500	144	90	22	1.60000E-08
21-11A	C3G	150-160	2	654	550	104	.	16	1.60000E-08
21-11B	C3G	160-170	0	655	550	105	.	16	1.60000E-08

Soil 21

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
21-1	AP	0-15	6.5	6.7	17	103	3.20000E-07	2.00000E-07
21-2	A12	15-23	6.4	6.8	7	35	4.00000E-07	1.60000E-07
21-3	A13	23-38	6.6	7.1	4	23	2.50000E-07	7.90000E-08
21-4	A14	38-53	7.1	7.2	5	31	7.90000E-08	6.30000E-08
21-5	B21	53-61	7.1	7.3	3	21	7.90000E-08	5.00000E-08
21-6	B22	61-71	7.3	7.4	3	21	5.00000E-08	4.00000E-08
21-7A	B31	71-84	7.4	7.4	3	22	4.00000E-08	4.00000E-08
21-7B	B31	84-99	7.8	7.5	3	21	1.60000E-08	3.20000E-08
21-8	B32	99-109	8.2	7.6	3	21	6.30000E-09	2.50000E-08
21-9	C1G	109-127	8.3	7.6	2	26	5.00000E-09	2.50000E-08
21-10A	C2G	127-140	8.4	7.6	2	27	4.00000E-09	2.50000E-08
21-10B	C2G	140-150	8.4	7.6	2	28	4.00000E-09	2.50000E-08
21-11A	C3G	150-160	.	.	.	.	.	.
21-11B	C3G	160-170	.	.	.	.	.	.

Soil 22-1

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
22-1	A11	0-13	7	13	6.1	1.7	68.4	29.9	3.7
22-2A	A12	13-28	21	15	5.8	.	.	.	3.2
22-2B	A12	28-43	36	15	6.0	.	.	.	2.8
22-3A	B21	43-59	51	16	6.2	3.0	61.0	36.0	1.6
22-3B	B21	59-71	65	12	6.4	.	.	.	1.3
22-4A	B22	71-79	75	8	6.4	3.8	61.9	34.3	1.2
22-4B	B22	79-89	84	10	6.5	.	.	.	0.9
22-5A	B23	89-99	94	10	6.6	.	.	.	0.8
22-5B	B23	99-109	104	10	6.7	5.4	62.0	32.6	.
22-6A	B3	109-119	114	10	6.5	.	.	.	.
22-6B	B3	119-130	125	11	6.7	.	.	.	.
22-7	C1G	130-145	138	15	6.9	8.8	52.4	28.6	.
22-8	C2G	145-152	149	7	6.9	.	.	.	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION	TK
22-1	A11	0-13	20	784	363	421	88	54	7.90000E-07	1.8
22-2A	A12	13-28	17	682	275	407	79	60	0.0000016	1.6
22-2B	A12	28-43	9	594	238	356	79	60	1.00000E-06	1.4
22-3A	B21	43-59	9	450	238	212	75	47	6.30000E-07	1.5
22-3B	B21	59-71	8	410	225	185	70	45	4.00000E-07	1.5
22-4A	B22	71-79	9	339	250	139	86	36	4.00000E-07	1.4
22-4B	B22	79-89	11	442	300	142	63	32	3.20000E-07	1.7
22-5A	B23	89-99	13	441	350	91	88	21	2.50000E-07	.
22-5B	B23	99-109	11	490	413	77	.	16	2.00000E-07	.
22-6A	B3	109-119	12	483	425	58	.	12	3.20000E-07	.
22-6B	B3	119-130	12	533	450	83	.	16	2.00000E-07	.
22-7	C1G	130-145	12	600	550	150	.	25	1.30000E-07	1.7
22-8	C2G	145-152	12	651	600	151	.	23	1.30000E-07	.

Soil 22-1

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
22-1	A11	0-13	6.2	6.5	31	554	6.30000E-07	3.20000E-07
22-2A	A12	13-28	5.9	6.2	11	213	0.0000013	6.30000E-07
22-2B	A12	28-43	6.3	6.6	9	70	5.00000E-07	2.50000E-07
22-3A	B21	43-59	6.5	6.9	9	36	3.20000E-07	1.30000E-07
22-3B	B21	59-71	6.6	6.9	9	31	2.50000E-07	1.30000E-07
22-4A	B22	71-79	6.7	7.1	8	24	2.00000E-07	7.90000E-08
22-4B	B22	79-89	6.6	7.1	9	34	2.50000E-07	7.90000E-08
22-5A	B23	89-99	6.7	7.2	12	26	2.00000E-07	6.30000E-08
22-5B	B23	99-109	6.8	7.2	12	27	1.60000E-07	6.30000E-08
22-6A	B3	109-119	7.0	7.3	13	27	1.00000E-07	5.00000E-08
22-6B	B3	119-130	7.1	7.4	12	28	7.90000E-08	4.00000E-08
22-7	C1G	130-145	7.1	7.2	13	26	7.90000E-08	6.30000E-08
22-8	C2G	145-152	7.2	7.5	13	21	6.30000E-08	3.20000E-08

Soil 22-2

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
22-1A	AP	0-10	5	10	6.9	2.6	68.3	29.1	3.5
22-1B	AP	10-20	15	10	6.7	.	.	.	3.3
22-2	A12	20-33	27	13	6.6	.	.	.	3.1
22-3A	A13	33-46	40	13	6.6	2.4	65.1	32.5	3.8
22-3B	A13	46-59	53	13	6.6	3.4	64.1	32.5	2.7
22-4A	A14	59-64	62	5	6.7	4.5	64.7	30.8	2.0
22-4B	A14	64-74	69	10	6.8	.	.	.	1.7
22-5A	A15	74-84	79	10	6.8	3.8	64.8	31.4	1.2
22-5B	A15	84-94	89	10	7.0	.	.	.	1.2
22-6A	AC	94-104	99	10	7.0	3.6	63.5	29.3	1.1
22-6B	AC	104-117	111	13	6.8	.	.	.	.
22-7	C1	117-127	122	10	7.1	2.7	69.3	28.0	.
22-8	C2G	127-140	134	13	7.3	2.4	73.1	24.5	.
22-9	C3G	140-152	146	12	7.4	2.5	73.9	23.6	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
22-1A	AP	0-10	60	829	400	429	82	52	1.30000E-07
22-1B	AP	10-20	24	690	300	390	85	57	2.00000E-07
22-2	A12	20-33	16	761	250	511	61	67	2.50000E-07
22-3A	A13	33-46	12	829	400	429	89	52	2.50000E-07
22-3B	A13	46-59	14	758	425	333	81	44	2.50000E-07
22-4A	A14	59-64	17	758	538	220	91	29	2.00000E-07
22-4B	A14	64-74	11	746	550	196	87	26	1.60000E-07
22-5A	A15	74-84	17	653	500	153	78	23	1.60000E-07
22-5B	A15	84-94	18	663	600	63	190	10	1.00000E-07
22-6A	AC	94-104	18	587	400	187	59	32	1.00000E-07
22-6B	AC	104-117	18	563	400	163	.	29	1.60000E-07
22-7	C1	117-127	17	440	363	77	.	18	7.90000E-08
22-8	C2G	127-140	13	394	375	19	.	5	5.00000E-08
22-9	C3G	140-152	11	443	425	18	.	4	4.00000E-08

Soil 24

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
24-1	AP	0-18	9	18	6.2	1.0	59.2	39.8	2.6
24-2	A12	18-33	26	15	5.5	.	.	.	2.6
24-3	A13	33-53	43	20	5.8	1.0	61.3	37.7	2.5
24-4	B1	53-74	61	21	6.0	.	.	.	1.9
24-5	B21	74-84	79	10	6.4	1.9	62.2	36.0	1.5
24-6	B22	84-104	94	20	6.8	.	.	.	1.3
24-7	B31	104-123	114	19	6.9	6.2	57.5	36.3	1.1
24-8	B32	123-135	129	12	6.9	.	.	.	.
24-9	C	135-147	141	12	7.0	12.8	57.6	29.6	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION	TK
24-1	AP	0-18	30	792	425	367	71	46	6.30000E-07	1.2
24-2	A12	18-33	24*	761	375	386	67	51	0.0000032	.
24-3	A13	33-53	18	594	250	344	73	58	0.0000016	.
24-4	B1	53-74	18*	392	200	192	99	49	1.00000E-06	.
24-5	B21	74-84	17*	336	125	211	71	63	4.00000E-07	1.1
24-6	B22	84-104	18	404	300	104	125	26	1.60000E-07	.
24-7	B31	104-123	18*	464	375	89	124	19	1.30000E-07	.
24-8	B32	123-135	18*	522	425	97	.	19	1.30000E-07	1.4
24-9	C	135-147	18	485	388	97	.	20	1.00000E-07	.

Soil 29

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
29-1	AP	0-20	10	20	7.1	29.9	43.9	26.2	2.9
29-2	A12	20-33	27	13	6.9	.	.	.	2.8
29-3	A13	33-48	41	15	6.6	29.5	43.0	27.5	3.3
29-4	A14	48-61	55	13	6.6	.	.	.	3.0
29-5A	B2	61-76	69	15	6.7	29.5	42.2	28.3	1.0
29-5B	B2	76-97	87	21	6.8	.	.	.	0.8
29-6	B3	97-112	105	15	6.7	27.5	44.6	27.9	0.9
29-7	BC	112-123	118	11	6.8	.	.	.	.
29-8	CG	123-152	138	29	6.8	25.3	45.9	28.6	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION	TK
29-1	AP	0-20	103	900	587	313	92	54	7.90000E-08	1.4
29-2	A12	20-33	78*	788	512	276	101	35	1.30000E-07	.
29-3	A13	33-48	53	746	300	446	74	60	2.50000E-07	.
29-4	A14	48-61	48*	654	162	492	61	75	2.50000E-07	1.9
29-5A	B2	61-76	43*	446	250	196	51	44	2.00000E-07	.
29-5B	B2	76-97	38	373	168	205	39	55	1.60000E-07	.
29-6	B3	97-112	33*	410	200	210	43	51	2.00000E-07	.
29-7	BC	112-123	29*	429	325	104	.	24	1.60000E-07	.
29-8	CG	123-152	22	492	375	117	.	27	1.60000E-07	1.6

Soil 29

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
29-1	AP	0-20	6.5	7.1	103	178	3.20000E-07	7.90000E-08
29-2	A12	20-33	7.6	7.3	91	133	2.50000E-08	5.00000E-08
29-3	A13	33-48	7.1	7.1	37	31	7.90000E-08	7.90000E-08
29-4	A14	48-61	7.0	7.1	17	19	1.00000E-07	7.90000E-08
29-5A	B2	61-76	7.2	7.3	14	14	6.30000E-08	5.00000E-08
29-5B	B2	76-97	7.4	7.5	19	9	4.00000E-08	3.20000E-08
29-6	B3	97-112	7.5	7.5	17	10	3.20000E-08	3.20000E-08
29-7	BC	112-123	7.5	7.5	25	16	3.20000E-08	3.20000E-08
29-8	CG	123-152	7.3	7.3	29	26	5.00000E-08	5.00000E-08

Soil 31-1

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
31-1A	AP	0-10	5	10	7.0	4.0	67.9	28.1	2.7
31-1B	AP	10-20	15	10	6.7	.	.	.	2.4
31-2	A12	20-36	28	16	7.0	.	.	.	2.4
31-3	A13	36-51	44	15	7.0	.	.	.	1.8
31-4A	A14	51-64	58	13	7.3	3.9	65.6	30.5	1.4
31-4B	A14	64-74	69	10	7.3	.	.	.	1.0
31-5A	A15	74-86	80	12	7.3	.	.	.	0.9
31-5B	A15	86-99	93	13	7.4	5.7	66.1	28.2	0.7
31-6A	AC	99-112	106	13	7.4	.	.	.	0.5
31-6B	AC	112-124	118	12	7.4	4.8	68.2	27.0	.
31-7A	CG	124-137	132	13	7.5	.	.	.	.
31-7B	CG	137-152	145	15	7.5	5.3	69.6	25.1	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
31-1A	AP	0-10	45	896	550	346	78	39	1.00000E-07
31-1B	AP	10-20	38	900	525	425	64	42	2.00000E-07
31-2	A12	20-36	17	854	500	354	68	41	1.00000E-07
31-3	A13	36-51	19	825	475	350	51	42	1.00000E-07
31-4A	A14	51-64	15	750	475	275	51	37	5.00000E-08
31-4B	A14	64-74	20	754	500	254	39	34	5.00000E-08
31-5A	A15	74-86	20	743	500	243	37	33	5.00000E-08
31-5B	A15	86-99	17	606	475	131	53	22	4.00000E-08
31-6A	AC	99-112	19	554	438	116	43	21	4.00000E-08
31-6B	AC	112-124	22	533	425	108	.	20	4.00000E-08
31-7A	CG	124-137	17	441	375	66	.	15	3.20000E-08
31-7B	CG	137-152	20	567	525	42	.	7	3.20000E-08

Soil 31-2

SOIL	HORIZCN	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
31-1A	AP	0-5	3	5	5.3	1.8	68.2	30.9	3.7
31-1B	AP	5-10	8	5	5.3	1.8	68.2	30.9	3.6
31-1C	AP	10-15	13	5	5.3	2.3	67.2	30.5	3.6
31-1D	AP	15-20	18	5	5.7	7.0	63.5	29.5	3.5
31-2A	A12	20-25	23	5	5.9	5.1	65.4	29.5	3.2
31-2B	A12	25-30	28	5	6.2	7.2	62.5	30.3	2.5
31-3A	A13	30-36	33	6	6.3	6.8	61.2	32.0	2.2
31-3B	A13	36-41	39	5	6.2	5.9	63.4	30.7	2.2
31-3C	A13	41-46	44	5	6.2	4.3	63.6	32.1	2.1
31-3D	A13	46-51	49	5	6.4	4.9	62.7	32.4	1.9
31-3E	A13	51-56	54	5	6.5	4.0	63.7	32.3	1.7
31-4A	A14	56-61	59	5	6.5	4.0	63.2	32.8	1.6
31-4B	A14	61-66	64	5	6.6	3.8	64.1	32.1	1.5
31-4C	A14	66-71	69	5	6.5	4.6	63.5	31.9	1.3
31-5A	A15	71-76	74	5	6.6	3.4	64.4	32.2	1.3
31-5B	A15	76-81	79	5	6.5	3.9	64.0	32.1	1.3
31-5C	A15	81-86	84	5	6.5	3.5	64.8	31.7	1.2
31-5D	A15	86-91	89	5	6.4	2.9	65.2	31.9	1.3
31-6A	A16	91-97	94	6	6.6	4.3	65.8	29.9	1.3
31-6B	A16	97-102	100	5	6.5	3.8	66.5	29.7	1.0
31-6C	A16	102-107	105	5	6.5	5.3	66.3	28.4	1.0
31-7A	C1	107-112	110	5	6.6	4.2	66.8	29.0	1.0
31-7B	C1	112-123	118	11	6.7	5.1	66.5	28.4	1.1
31-7C	C1	123-132	128	9	6.5	4.8	66.1	29.1	1.0
31-8A	C2	132-142	137	10	6.7	5.0	66.4	28.6	1.1
31-8B	C2	142-152	147	10	6.6	5.6	66.4	28.0	1.1

Soil 31-2

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION	TK
31-1A	AP	0-5	60	938	425	513	72	55	0.000005	2.1
31-1B	AP	5-10	56	.	.	.	.	.	0.000005	.
31-1C	AP	10-15	33	897	425	472	76	53	0.000005	.
31-1D	AP	15-20	30	.	.	.	.	.	0.000002	.
31-2A	A12	20-25	21	848	538	310	103	37	0.0000013	.
31-2B	A12	25-30	22	.	.	.	.	.	6.30000E-07	.
31-3A	A13	30-36	29	844	625	219	132	26	5.00000E-07	.
31-3B	A13	36-41	30	.	.	.	.	.	6.30000E-07	.
31-3C	A13	41-46	39	741	525	216	97	29	6.30000E-07	.
31-3D	A13	46-51	38	.	.	.	.	.	4.00000E-07	.
31-3E	A13	51-56	37	649	525	124	137	19	3.20000E-07	1.1
31-4A	A14	56-61	37	.	.	.	.	.	3.20000E-07	.
31-4B	A14	61-66	35	608	463	145	103	24	2.50000E-07	.
31-4C	A14	66-71	37	.	.	.	.	.	3.20000E-07	.
31-5A	A15	71-76	37	552	436	114	114	21	2.50000E-07	.
31-5B	A15	76-81	40	.	.	.	.	.	3.20000E-07	.
31-5C	A15	81-86	39	520	438	82	146	16	3.20000E-07	.
31-5D	A15	86-91	40	.	.	.	.	.	4.00000E-07	1.2
31-6A	A16	91-97	41	565	475	90	144	16	2.50000E-07	.
31-6B	A16	97-102	41	.	.	.	.	.	3.20000E-07	.
31-6C	A16	102-107	38	569	463	106	94	10	3.20000E-07	.
31-7A	C1	107-112	39	.	.	.	.	.	2.50000E-07	.
31-7B	C1	112-123	38	546	438	108	102	20	2.00000E-07	.
31-7C	C1	123-132	39	.	.	.	.	.	3.20000E-07	.
31-8A	C2	132-142	39	547	450	97	113	18	2.00000E-07	.
31-8B	C2	142-152	38	.	.	.	.	.	2.50000E-07	1.2

Soil 31-2

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
31-1A	AP	0-5	5.7	6.4	59	162	0.000002	4.00000E-07
31-1B	AP	5-10	5.7	6.3	59	226	0.000002	5.00000E-07
31-1C	AP	10-15	5.7	6.4	57	215	0.000002	4.00000E-07
31-1D	AP	15-20	5.8	6.4	33	185	0.0000016	4.00000E-07
31-2A	A12	20-25	6.0	6.5	21	94	1.00000E-06	3.20000E-07
31-2B	A12	25-30	6.3	6.7	24	55	5.00000E-07	2.00000E-07
31-3A	A13	30-36	6.4	6.9	25	47	4.00000E-07	1.30000E-07
31-3B	A13	36-41	6.5	6.9	23	36	3.20000E-07	1.30000E-07
31-3C	A13	41-46	6.6	6.8	25	31	2.50000E-07	1.60000E-07
31-3D	A13	46-51	6.7	6.9	36	33	2.00000E-07	1.30000E-07
31-3E	A13	51-56	6.8	6.9	34	29	1.60000E-07	1.30000E-07
31-4A	A14	56-61	6.8	7.1	37	25	1.60000E-07	7.90000E-08
31-4B	A14	61-66	6.8	7.1	35	29	1.60000E-07	7.90000E-08
31-4C	A14	66-71	6.9	7.1	37	25	1.30000E-07	7.90000E-08
31-5A	A15	71-76	6.8	7.1	33	29	1.60000E-07	7.90000E-08
31-5B	A15	76-81	6.8	7.1	37	33	1.60000E-07	7.90000E-08
31-5C	A15	81-86	6.8	7.1	35	32	1.60000E-07	7.90000E-08
31-5D	A15	86-91	6.8	7.0	36	42	1.60000E-07	1.00000E-07
31-6A	A16	91-97	6.5	7.1	37	45	3.20000E-07	7.90000E-08
31-6B	A16	97-102	6.8	7.1	37	33	1.60000E-07	7.90000E-08
31-6C	A16	102-107	6.9	7.2	34	31	1.30000E-07	6.30000E-08
31-7A	C1	107-112	6.8	7.1	38	39	1.60000E-07	7.90000E-08
31-7B	C1	112-123	6.8	7.2	37	37	1.30000E-07	6.30000E-08
31-7C	C1	123-132	7.0	7.2	32	38	1.00000E-07	6.30000E-08
31-8A	C2	132-142	.	.	.	.	.	.
31-8B	C2	142-152	.	.	.	.	.	.

Soil 36

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
36-1	AP	0-18	6.6	7.0	89	143	2.50000E-07	1.00000E-07
36-2	A12	18-28	6.5	7.0	73	106	3.20000E-07	1.00000E-07
36-3	A13	28-41	6.6	7.1	25	31	2.50000E-07	7.90000E-08
36-4A	A14	41-51	6.9	7.2	24	30	1.30000E-07	6.30000E-08
36-4B	A14	51-61	7.0	7.2	26	30	1.00000E-07	6.30000E-08
36-5	A15	61-79	7.0	7.4	20	26	1.00000E-07	4.00000E-08
36-6A	B2	79-89	7.2	7.4	17	27	6.30000E-08	4.00000E-08
36-6B	B2	89-99	7.4	7.4	17	28	4.00000E-08	4.00000E-08
36-7A	B3G	99-114	7.4	7.5	25	36	4.00000E-08	3.20000E-08
36-7B	B3G	114-127	7.3	7.4	32	48	5.00000E-08	4.00000E-08
36-7C	B3G	127-140	7.2	7.5	31	44	6.30000E-08	3.20000E-08
36-8	CG	140-152	7.3	7.4	28	38	5.00000E-08	4.00000E-08

Soil 36

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
36-1	AP	0-18	9	18	5.9	2.2	72.2	35.6	2.4
36-2	A12	18-28	23	10	6.0	.	.	.	2.4
36-3	A13	28-41	35	13	6.2	2.4	63.3	34.3	2.0
36-4A	A14	41-51	46	10	6.3	2.5	62.3	35.2	2.0
36-4B	A14	51-61	56	10	6.4	.	.	.	1.7
36-5	A15	61-79	70	18	6.5	2.6	64.4	33.0	1.3
36-6A	B2	79-89	84	10	6.6	.	.	.	0.8
36-6B	B2	89-99	94	10	6.6	2.6	55.2	32.2	0.6
36-7A	B3G	99-114	107	15	6.7	.	.	.	0.4
36-7B	B3G	114-127	121	13	6.7	2.7	64.1	33.2	.
36-7C	B3G	127-140	134	13	6.7	.	.	.	0.5
36-8	CG	140-152	146	12	6.7	3.1	65.6	31.3	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION	TK
36-1	AP	0-18	50	684	425	259	93	38	0.0000013	1.3
36-2	A12	18-28	40*	650	338	312	77	48	1.00000E-06	.
36-3	A13	28-41	28	544	275	269	74	49	6.30000E-07	.
36-4A	A14	41-51	30*	528	250	278	72	53	5.00000E-07	1.4
36-4B	A14	51-61	32	536	88	448	38	84	4.00000E-07	.
36-5	A15	61-79	31*	522	150	372	35	71	3.20000E-07	.
36-6A	B2	79-89	30	443	213	230	35	52	2.50000E-07	.
36-6B	B2	89-99	32*	480	263	217	28	45	2.50000E-07	1.4
36-7A	B3G	99-114	36	557	375	182	22	33	2.00000E-07	.
36-7B	B3G	114-127	39*	588	263	325	.	55	2.00000E-07	.
36-7C	B3G	127-140	41	594	388	206	.24	35	2.00000E-07	.
36-8	CG	140-152	.	628	550	78	.	12	2.00000E-07	1.6

Soil 38

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
38-1	AP	0-20	10	20	6.5	12.9	58.0	29.1	1.6
38-2	A12	20-38	29	18	6.5	13.5	56.7	29.8	2.7
38-3	A12	38-61	50	23	6.4	14.9	55.4	29.7	1.5
38-4	B2	61-84	73	23	6.4	23.3	50.5	26.2	0.9
38-5	B31	84-107	96	23	6.4	20.5	47.7	31.8	0.8
38-6	B32	107-122	115	15	6.3	21.0	49.8	29.2	.
38-7	C	122-145	134	23	6.4	45.5	36.0	18.5	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
38-1	AP	0-20	55	844	488	356	45	42	3.20000E-07
38-2	A12	20-38	35*	671	300	371	73	55	3.20000E-07
38-3	A12	38-61	12	516	300	216	69	42	4.00000E-07
38-4	B2	61-84	18*	475	400	75	120	16	4.00000E-07
38-5	B31	84-107	24	505	425	80	100	16	4.00000E-07
38-6	B32	107-122	15*	578	488	90	.	16	5.00000E-07
38-7	C	122-145	7	525	488	37	.	7	4.00000E-07

Soil 43

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
43-1	AP	0-18	9	18	6.2	2.7	61.5	35.8	2.9
43-2	A12	18-38	28	20	6.1	.	.	.	1.9
43-3A	A13	38-51	45	13	6.1	2.5	63.0	34.5	1.6
43-3B	A13	51-61	56	10	6.0	.	.	.	1.2
43-4	B21	61-79	70	18	6.0	.	.	.	1.0
43-5	B22	79-94	87	15	6.0	2.6	63.0	34.4	0.9
43-6	B23	94-104	99	10	6.1	2.7	64.2	33.1	0.7
43-7	B31	104-122	113	18	6.1	.	.	.	.
43-8	B32	122-137	130	15	6.2	1.8	64.1	34.1	.
43-9	C	137-152	145	15	6.2	1.8	66.6	31.6	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION	TK
43-1	AP	0-18	73	1013	775	238	122	23	6.30000E-07	1.2
43-2	A12	18-38	62*	806	600	206	92	26	7.90000E-07	.
43-3A	A13	38-51	52	750	575	175	91	23	7.90000E-07	1.6
43-3B	A13	51-61	51*	675	525	150	80	22	1.00000E-06	.
43-4	B21	61-79	53	603	475	128	78	21	1.00000E-06	.
43-5	B22	79-94	60*	656	325	331	27	50	1.00000E-06	.
43-6	B23	94-104	65	678	675	.	.	.	7.90000E-07	1.1
43-7	B31	104-122	78*	694	650	44	.	6	7.90000E-07	.
43-8	B32	122-137	70	746	700	46	.	6	6.30000E-07	.
43-9	C	137-152	.	787	700	88	.	11	6.30000E-07	1.7

Soil 43

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
43-1	AP	0-18	6.3	6.7	64	187	5.00000E-07	2.00000E-07
43-2	A12	18-38	6.5	6.9	37	57	3.20000E-07	1.30000E-07
43-3A	A13	38-51	6.5	7.0	36	37	3.20000E-07	1.00000E-07
43-3B	A13	51-61	6.6	7.0	41	29	2.50000E-07	1.00000E-07
43-4	B21	61-79	6.4	7.0	42	29	4.00000E-07	1.00000E-07
43-5	B22	79-94	6.4	7.0	50	40	4.00000E-07	1.00000E-07
43-6	B23	94-104	6.5	7.1	46	40	3.20000E-07	7.90000E-08
43-7	B31	104-122	6.5	7.1	55	42	3.20000E-07	7.90000E-08
43-8	B32	122-137	6.7	7.1	59	38	2.00000E-07	7.90000E-08
43-9	C	137-152	6.3	7.2	60	33	5.00000E-07	6.30000E-08

Soil 44

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
44-1	A11	0-15	8	15	6.8	0.6	66.1	33.3	2.5
44-2	A12	15-30	23	15	6.5	0.8	60.3	38.9	2.7
44-3	A13	30-43	37	13	6.5	1.0	60.2	38.8	2.4
44-4	A14	43-61	52	18	6.5	1.3	62.0	36.7	2.1
44-5	B21	61-81	71	20	6.6	1.6	61.1	37.3	1.7
44-6	B22	81-99	90	18	6.7	1.2	60.6	38.1	1.1
44-7	B23	99-123	111	24	6.7	1.3	61.7	37.0	0.7
44-8	B3G	123-140	132	17	6.8	1.4	63.4	35.2	.
44-9	CG	140-152	146	12	6.8	3.3	62.0	34.7	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	CP	OC/OP	OP/TP	HION
44-1	A11	0-15	53	731	425	306	82	42	1.60000E-07
44-2	A12	15-30	42*	743	375	368	73	50	3.20000E-07
44-3	A13	30-43	36	748	425	323	74	43	3.20000E-07
44-4	A14	43-61	38*	796	425	371	57	47	3.20000E-07
44-5	B21	61-81	40	713	450	263	65	37	2.50000E-07
44-6	B22	81-99	47*	713	425	288	38	40	2.00000E-07
44-7	B23	99-123	57	641	512	129	54	20	2.00000E-07
44-8	B3G	123-140	58*	616	475	141	.	23	1.60000E-07
44-9	CG	140-152	59	750	625	125	.	17	1.60000E-07

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
44-1	A11	0-15	6.9	7.0	52	223	1.30000E-07	1.00000E-07
44-2	A12	15-30	7.0	7.0	39	109	1.00000E-07	1.00000E-07
44-3	A13	30-43	6.9	7.0	29	33	1.30000E-07	1.00000E-07
44-4	A14	43-61	7.1	7.1	32	31	7.90000E-08	7.90000E-08
44-5	B21	61-81	7.0	7.1	37	32	1.00000E-07	7.90000E-08
44-6	B22	81-99	7.2	7.4	27	19	6.30000E-08	4.00000E-08
44-7	B23	99-123	7.3	7.5	37	28	5.00000E-08	3.20000E-08
44-8	B3G	123-140	7.3	7.4	36	32	5.00000E-08	4.00000E-08
44-9	CG	140-152	7.2	7.3	48	51	6.30000E-08	5.00000E-08

Soil 48

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
48-1	AP	0-15	8	15	6.8	8.4	64.6	27.0	2.5
48-2	A12	15-30	23	15	6.6	5.6	64.2	30.2	2.6
48-3A	B1	30-46	38	16	6.2	2.3	62.9	34.8	2.5
48-3B	B1	46-61	54	15	6.2	2.7	61.5	35.8	1.7
48-4A	B2	61-76	69	15	6.3	2.3	61.4	36.3	1.0
48-4B	B2	76-89	83	13	6.5	3.2	62.4	34.5	0.9
48-5	B31	89-109	99	20	6.8	3.2	63.8	33.1	0.6
48-6	B32	109-123	116	14	6.8	2.1	66.9	31.0	.
48-7	C1G	123-137	130	14	6.9	3.1	67.3	29.6	.
48-8	C2G	137-152	145	15	6.9	5.0	66.2	28.8	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	CP	OC/OP	OP/TP	HION
48-1	AP	0-15	33	528	175	353	71	67	1.60000E-07
48-2	A12	15-30	25*	522	175	347	75	66	2.50000E-07
48-3A	B1	30-46	18*	436	162	274	91	63	6.30000E-07
48-3B	B1	46-61	11	375	175	200	85	53	6.30000E-07
48-4A	B2	61-76	11*	358	225	133	75	37	5.00000E-07
48-4B	B2	76-89	12*	379	225	154	58	41	3.20000E-07
48-5	B31	89-109	12	375	277	98	61	26	1.60000E-07
48-6	B32	109-123	15*	319	225	94	.	29	1.60000E-07
48-7	C1G	123-137	16*	299	225	74	.	25	1.30000E-07
48-8	C2G	137-152	18	302	250	52	.	17	1.30000E-07

Soil 48

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
48-1	AP	0-15	7.3	7.3	28	75	5.00000E-08	5.00000E-08
48-2	A12	15-30	6.8	6.9	11	26	1.60000E-07	1.30000E-07
48-3A	B1	30-46	6.5	6.8	10	19	3.20000E-07	1.60000E-07
48-3B	B1	46-61	6.7	7.1	12	18	2.50000E-07	7.90000E-08
48-4A	B2	61-76	6.8	7.1	11	25	1.60000E-07	7.90000E-08
48-4B	B2	76-89	7.0	7.2	9	23	1.00000E-07	6.30000E-08
48-5	B31	89-109	7.5	7.4	9	26	3.20000E-08	4.00000E-08
48-6	B32	109-123	7.4	7.4	15	33	4.00000E-08	4.00000E-08
48-7	C1G	123-137	7.5	7.4	15	33	3.20000E-08	4.00000E-08
48-8	C2G	137-152	7.6	7.5	16	29	2.50000E-08	3.20000E-08

Soil 52

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
52-1	A11	0-18	9	18	6.0	3.3	73.8	23.0	0.9
52-2	A12	18-38	28	20	6.3	4.4	69.1	26.5	1.1
52-3A	B21	38-51	45	13	6.4	9.9	53.9	36.2	2.3
52-3B	B21	51-61	56	10	6.4	9.0	52.7	38.8	2.4
52-4	B22	61-76	69	15	6.5	10.2	50.4	39.4	0.6
52-5	B23	76-94	85	18	6.5	12.4	51.2	36.4	0.2
52-6	B3G	94-109	102	15	6.7	15.8	52.0	32.2	0.0
52-7	CG	109-123	116	14	6.7	16.2	51.6	32.2	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HIGN	TK
52-1	A11	0-18	47	563	325	238	38	42	1.00000E-06	1.8
52-2	A12	18-38	32*	584	212	372	30	64	5.00000E-07	.
52-3A	B21	38-51	18	678	225	453	51	67	4.00000E-07	1.7
52-3B	B21	51-61	28*	754	163	591	41	78	4.00000E-07	.
52-4	B22	61-76	38	784	212	572	10	73	3.20000E-07	.
52-5	B23	76-94	47*	773	475	298	7	39	3.20000E-07	.
52-6	B3G	94-109	55	754	650	104	.	14	2.00000E-07	1.4
52-7	CG	109-123	.	900	800	100	.	11	2.00000E-07	.

Soil 52

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
52-1	A11	0-18	6.4	6.9	38	102	4.00000E-07	1.30000E-07
52-2	A12	18-38	6.7	7.0	27	49	2.00000E-07	1.00000E-07
52-3A	B21	38-51	6.7	7.0	18	23	2.00000E-07	1.00000E-07
52-3B	B21	51-61	7.1	7.4	17	16	7.90000E-08	4.00000E-08
52-4	B22	61-76	7.0	7.3	28	20	1.00000E-07	5.00000E-08
52-5	B23	76-94	7.2	7.5	28	12	6.30000E-08	3.20000E-08
52-6	B3G	94-109	7.1	7.3	51	28	7.90000E-08	5.00000E-08
52-7	CG	109-123	7.2	7.4	46	26	6.30000E-08	4.00000E-08

Soil 54

SOIL	HORIZON	DEPTH CM	MDPT CM	WSTPT	PH	SAND	SILT	CLAY	TC
54-1	AP	0-20	10	20	6.4	9.1	66.1	24.8	1.7
54-2	A12	20-36	28	16	6.3	7.1	66.8	26.1	1.7
54-3A	A13	36-51	44	15	5.8	3.7	65.8	30.5	2.7
54-3B	A13	51-66	59	15	5.7	7.6	59.9	32.5	2.7
54-4A	B1	66-79	73	13	5.8	7.5	56.2	36.3	2.1
54-4B	B1	79-91	85	12	5.7	7.0	55.3	37.7	1.5
54-5	B21	91-104	98	13	5.8	7.0	54.4	38.6	1.1
54-6	B22G	104-123	114	19	5.9	6.1	55.8	38.1	0.7
54-7	B23G	123-135	129	12	5.8	6.0	58.0	36.2	.
54-8	B3G	135-152	144	17	6.1	6.1	60.1	35.3	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
54-1	AP	0-20	44	633	375	258	66	41	4.00000E-07
54-2	A12	20-36	32*	546	200	346	49	63	5.00000E-07
54-3A	A13	36-51	21*	588	200	388	70	66	0.0000016
54-3B	A13	51-66	12	570	175	395	68	69	0.000002
54-4A	B1	66-79	11*	485	175	310	68	64	0.0000016
54-4B	B1	79-91	9*	367	150	217	69	59	0.000002
54-5	B21	91-104	7	339	125	214	51	63	0.0000016
54-6	B22G	104-123	7*	310	150	160	44	52	0.0000013
54-7	B23G	123-135	6*	317	200	117	.	37	1.00000E-06
54-8	B3G	135-152	5	396	300	96	.	24	7.90000E-07

Soil 56

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
56-1A	AP	0-13	7	13	6.2	3.1	67.7	29.2	2.6
56-1B	AP	13-23	18	10	6.0	.	.	.	2.5
56-2	A12	23-41	32	18	6.3	8.8	61.8	29.4	2.2
56-3	A13	41-61	51	20	6.4	.	.	.	1.4
56-4A	B21	61-76	69	15	6.5	2.5	65.0	32.5	0.5
56-4B	B21	76-91	84	15	6.6	.	.	.	0.1
56-5	B22G	91-107	99	16	6.7	.	.	.	0.0
56-6	B23G	107-123	115	16	6.9	3.8	61.9	34.3	.
56-7	B3G	123-135	129	12	6.8	.	.	.	.
56-8	CG	135-152	144	17	6.8	2.0	61.6	36.4	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION	TK
56-1A	AP	0-13	23	341	237	304	86	56	6.30000E-07	1.5
56-1B	AP	13-23	18*	528	150	378	66	72	1.00000E-07	.
56-2	A12	23-41	11*	469	175	294	75	63	5.00000E-07	.
56-3	A13	41-61	4	339	175	164	85	48	4.00000E-07	.
56-4A	B21	61-76	4*	300	175	125	40	42	3.20000E-07	1.2
56-4B	B21	76-91	4*	339	237	102	10	30	2.50000E-07	.
56-5	B22G	91-107	3	339	267	72	.	21	2.00000E-07	.
56-6	B23G	107-123	6*	358	238	120	.	34	1.30000E-07	1.5
56-7	B3G	123-135	9*	417	250	167	.	40	1.60000E-07	.
56-8	CG	135-152	13	448	338	110	.	25	1.60000E-07	1.3

Soil 56

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
56-1A	AP	0-13	6.4	6.9	24	65	4.00000E-07	1.30000E-07
56-1B	AP	13-23	5.8	6.7	22	60	0.0000016	2.00000E-07
56-2	A12	23-41	6.7	7.0	10	27	2.00000E-07	1.00000E-07
56-3	A13	41-61	6.9	7.3	6	18	1.30000E-07	5.00000E-08
56-4A	B21	61-76	7.2	7.5	5	18	6.30000E-08	3.20000E-08
56-4B	B21	76-91	7.3	7.5	5	17	5.00000E-08	3.20000E-08
56-5	B22G	91-107	7.4	7.5	6	11	4.00000E-08	3.20000E-08
56-6	B23G	107-123	7.4	7.5	6	19	4.00000E-08	3.20000E-08
56-7	B3G	123-135	7.2	7.3	11	25	6.30000E-08	5.00000E-08
56-8	CG	135-152	7.4	7.5	10	24	4.00000E-08	3.20000E-08

Soil 60

SOIL	HORIZON	DEPTH CM	MDPT CM	#GTPT	PH	SAND	SILT	CLAY	TC
60-1	AP	0-18	9	18	5.0	5.9	60.6	33.5	3.0
60-2A	A12	18-28	23	10	5.8	4.6	60.8	34.6	1.8
60-2B	A12	28-38	33	10	6.1	4.2	60.8	35.0	1.7
60-3A	A13	38-53	46	15	6.7	3.6	60.6	35.8	1.8
60-3B	A13	53-71	62	18	6.9	3.6	61.7	34.7	1.1
60-4A	A14	71-84	78	13	7.0	4.3	66.1	29.6	1.0
60-4B	A14	84-99	92	15	7.2	4.1	69.0	26.9	0.8
60-5A	C1	99-109	104	10	7.2	4.2	72.2	23.6	1.1
60-5B	C1	109-123	116	14	7.3	5.1	71.2	23.7	.
60-6	C2	123-145	134	22	7.3	4.8	71.6	23.6	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION	TK
60-1	AP	0-18	156	1101	450	651	46	59	0.000010000	1.3
60-2A	A12	18-28	36	924	250	674	27	73	0.000001600	1.3
60-2B	A12	28-38	40	541	100	441	39	82	0.000000790	1.3
60-3A	A13	38-53	37*	485	200	285	63	59	0.000000200	1.2
60-3B	A13	53-71	32*	448	237	211	52	47	0.000000130	1.0
60-4A	A14	71-84	28	560	212	348	29	62	0.000000100	1.2
60-4B	A14	84-99	17*	574	300	274	29	48	0.000000063	1.1
60-5A	C1	99-109	8	615	300	315	35	51	0.000000063	0.8
60-5B	C1	109-123	14*	596	412	184	.	31	0.000000050	0.7
60-6	C2	123-145	24	615	450	165	.	27	0.000000050	0.8

Soil 60

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
60-1	AP	0-18	5.4	6.0	85	349	0.000004	1.00000E-06
60-2A	A12	18-28	6.2	6.6	35	51	6.30000E-07	2.50000E-07
60-2B	A12	28-38	6.8	7.0	40	73	1.60000E-07	1.00000E-07
60-3A	A13	38-53	6.8	7.2	15	45	1.60000E-07	6.30000E-08
60-3B	A13	53-71	7.2	7.4	8	37	6.30000E-08	4.00000E-08
60-4A	A14	71-84	7.6	7.5	13	38	2.50000E-08	3.20000E-08
60-4B	A14	84-99	8.1	7.5	2	33	7.90000E-09	3.20000E-08
60-5A	C1	99-109	8.1	7.5	2	35	7.90000E-09	3.20000E-08
60-5B	C1	109-123	8.1	7.6	2	40	7.90000E-09	2.50000E-08
60-6	C2	123-145	8.1	7.6	13	50	7.90000E-09	2.50000E-08

Soil 62

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
62-1A	AP	0-10	5	10	6.2	1.1	72.6	26.3	2.4
62-1B	AP	10-20	15	10	5.8	11.2	62.2	26.6	2.4
62-2	A12	20-41	31	21	5.7	3.0	71.6	25.4	2.1
62-3	A13	41-61	51	20	5.7	11.5	61.7	26.8	2.0
62-4	A14	61-79	70	18	5.8	18.3	54.3	27.4	1.5
62-5	B1	79-94	87	15	5.9	17.6	52.0	30.4	1.4
62-6	B21	94-107	101	13	5.9	13.7	52.0	34.3	.
62-7	B22	107-119	113	12	6.0	9.5	52.5	38.0	.
62-8	B3	119-136	128	17	6.2	6.4	54.5	39.1	.
62-9	C	136-152	144	16	6.0	10.4	56.2	33.4	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
62-1A	AP	0-10	54	520	325	195	123	38	6.30000E-07
62-1B	AP	10-20	15	560	300	260	92	46	0.0000016
62-2	A12	20-41	13*	481	213	268	78	56	0.000002
62-3	A13	41-61	11*	464	200	264	76	57	0.000002
62-4	A14	61-79	10	464	175	289	52	62	0.0000016
62-5	B1	79-94	9*	373	100	273	51	73	0.0000013
62-6	B21	94-107	8	301	100	201	.	67	0.0000013
62-7	B22	107-119	9*	232	88	144	.	62	1.00000E-06
62-8	B3	119-136	10*	239	100	139	.	58	6.30000E-07
62-9	C	136-152	12	319	175	144	.	45	1.00000E-06

Soil 63

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
63-1A	AP	0-10	5	10	5.9	14.4	62.1	23.5	1.2
63-1B	AP	10-18	14	8	6.3	.	.	.	1.1
63-2	A12	18-33	26	15	6.5	.	.	.	1.1
63-3A	B21	33-43	38	10	6.5	.	.	.	1.0
63-3B	B21	43-56	50	13	6.6	3.9	65.0	31.1	0.9
63-3C	B21	56-69	63	13	6.7	.	.	.	0.8
63-4	B22	69-81	75	12	6.6	.	.	.	0.7
63-5	B23	81-94	88	13	6.8	2.0	66.3	31.7	0.7
63-6A	B3G	94-104	99	10	6.8	.	.	.	0.5
63-6B	B3G	104-114	109	10	6.9	.	.	.	.
63-7A	CG	114-132	123	18	6.9	.	.	.	.
63-7B	CG	132-152	142	20	6.8	2.4	66.9	30.7	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION	TK
63-1A	AP	0-10	29	373	213	160	75	43	0.0000013	1.3
63-1B	AP	10-18	27	372	213	159	69	43	5.00000E-07	.
63-2	A12	18-33	24	356	200	156	71	44	3.20000E-07	.
63-3A	B21	33-43	18	302	188	114	88	38	3.20000E-07	.
63-3B	B21	43-56	10	292	188	104	87	36	2.50000E-07	1.9
63-3C	B21	56-69	8	284	150	134	60	47	2.00000E-07	.
63-4	B22	69-81	8	262	175	87	80	33	2.50000E-07	.
63-5	B23	81-94	13	263	125	138	51	52	1.60000E-07	.
63-6A	B3G	94-104	19	290	188	102	49	35	1.60000E-07	.
63-6B	B3G	104-114	20	312	238	74	.	24	1.30000E-07	.
63-7A	CG	114-132	21	373	250	123	.	33	1.30000E-07	.
63-7B	CG	132-152	22	365	263	102	.	28	1.60000E-07	1.2

Soil 63

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
63-1A	AP	0-10	7.5	7.4	27	88	3.20000E-08	4.00000E-08
63-1B	AP	10-18	7.2	7.3	23	64	6.30000E-08	5.00000E-08
63-2	A12	18-33	6.8	7.2	18	44	1.60000E-07	6.30000E-08
63-3A	B21	33-43	6.8	7.2	9	27	1.60000E-07	6.30000E-08
63-3B	B21	43-56	7.0	7.3	6	26	1.00000E-07	5.00000E-08
63-3C	B21	56-69	6.9	7.3	8	25	1.30000E-07	5.00000E-08
63-4	B22	69-81	7.3	7.5	6	17	5.00000E-08	3.20000E-08
63-5	B23	81-94	7.3	7.6	7	17	5.00000E-08	3.20000E-08
63-6A	B3G	94-104	7.0	7.5	9	22	1.00000E-07	3.20000E-08
63-6B	B3G	104-114	7.1	7.3	13	25	7.90000E-08	5.00000E-08
63-7A	CG	114-132	7.2	7.5	14	26	6.30000E-08	3.20000E-08
63-7B	CG	132-152	7.2	7.5	15	27	6.30000E-08	3.20000E-08

Soil 71

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
71-1	AP	0-13	7	13	6.0	5.2	58.4	36.4	3.7
71-2	A12	13-28	21	15	6.5	.	.	.	2.8
71-3	A13	28-38	33	10	6.7	6.9	58.2	34.9	1.6
71-4	B1	38-51	45	13	7.2	.	.	.	1.2
71-5	B21	51-66	59	15	7.3	8.2	58.2	33.6	0.8
71-6	B22	66-81	74	15	7.4	.	.	.	0.6
71-7	B23	81-91	86	10	7.5	.	.	.	0.5
71-8	B24	91-102	97	11	7.4	1.3	63.8	34.9	0.6
71-9	B3G	102-112	107	10	7.8	.	.	.	.
71-10	C1G	112-123	118	11	7.7	.	.	.	.
71-11	C2G	123-130	127	7	8.0	.	.	.	.
71-12	C3G	130-152	141	22	7.9	7.5	59.1	33.4	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
71-1	AP	0-13	40	609	275	334	111	55	1.00000E-06
71-2	A12	13-28	28*	533	188	345	81	65	3.20000E-07
71-3	A13	28-38	16*	356	150	206	78	58	2.00000E-07
71-4	B1	38-51	6	313	175	138	87	44	6.30000E-08
71-5	B21	51-66	5*	303	188	115	70	38	5.00000E-08
71-6	B22	66-81	4*	302	213	89	67	29	4.00000E-08
71-7	B23	81-91	3	300	238	138	36	46	3.20000E-08
71-8	B24	91-102	4	302	225	77	78	25	4.00000E-08
71-9	B3G	102-112	5	377	275	102	.	27	1.60000E-08
71-10	C1G	112-123	3*	417	325	92	.	22	2.00000E-08
71-11	C2G	123-130	3*	455	350	105	.	23	1.00000E-08
71-12	C3G	130-152	3	497	488	9	.	2	1.30000E-08

Soil 73

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
73-1	AP	0-18	9	18	5.8	1.1	66.8	32.1	2.9
73-2	A12	18-36	27	18	5.9	.	.	.	2.4
73-3A	B1	36-48	42	12	6.2	0.9	64.9	34.3	1.6
73-3B	B1	48-64	56	16	6.4	1.1	66.0	32.9	1.5
73-4	B21	64-76	70	12	6.5	1.2	65.9	32.9	1.3
73-5A	B22	76-89	83	13	6.7	1.0	63.8	35.2	1.3
73-5B	B22	89-104	97	15	6.8	.	.	.	1.2
73-6	B23	104-123	114	19	6.7	1.1	61.0	37.9	1.2
73-7	B3	123-142	133	19	7.0	.	.	.	.
73-8	C	142-152	147	10	6.9	1.1	64.3	34.6	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
73-1	AP	0-18	70	653	200	453	64	69	0.0000016
73-2	A12	18-36	44*	525	325	200	120	38	0.0000013
73-3A	B1	36-48	10	450	325	125	128	28	6.30000E-07
73-3B	B1	48-64	11*	452	325	127	118	28	3.20000E-07
73-4	B21	64-76	13	469	438	313	419	67	3.20000E-07
73-5A	B22	76-89	20*	488	450	38	342	8	2.00000E-07
73-5B	B22	89-104	30	525	375	150	80	29	1.60000E-07
73-6	B23	104-123	33*	528	200	328	37	62	2.00000E-07
73-7	B3	123-142	36	525	300	225	.	43	1.00000E-07
73-8	C	142-152	.	560	350	210	.	38	1.30000E-07

Soil 73

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
73-1	AP	0-18	6.1	6.7	53	81	7.90000E-07	2.00000E-07
73-2	A12	18-36	6.2	6.9	24	24	6.30000E-07	1.30000E-07
73-3A	B1	36-48	6.5	7.2	7	20	3.20000E-07	6.30000E-08
73-3B	B1	48-64	7.0	7.3	7	18	1.00000E-07	5.00000E-08
73-4	B21	64-76	7.3	7.4	7	24	5.00000E-08	4.00000E-08
73-5A	B22	76-89	7.3	7.5	8	24	5.00000E-08	3.20000E-08
73-5B	B22	89-104	7.5	7.5	12	30	3.20000E-08	3.20000E-08
73-6	B23	104-123	7.4	7.4	19	27	4.00000E-08	4.00000E-08
73-7	B3	123-142	7.6	7.4	20	16	2.50000E-08	4.00000E-08
73-8	C	142-152	7.4	7.3	27	27	4.00000E-08	5.00000E-08

Soil 75

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
75-1	A11	0-15	8	15	6.0	1.8	64.0	34.2	5.0
75-2	A12	15-28	22	13	6.2	3.2	61.2	35.6	3.1
75-3	A13	28-38	33	10	6.4	•	•	•	2.9
75-4	B1	38-48	43	10	6.5	•	•	•	2.7
75-5	B21	48-61	55	13	6.6	3.4	61.9	34.7	2.2
75-6A	B22	61-76	69	15	6.8	•	•	•	1.2
75-6B	B22	76-94	85	18	6.8	3.2	61.5	35.3	0.9
75-7A	BC	94-107	101	13	7.0	•	•	•	0.5
75-7B	BC	107-123	115	16	7.0	7.5	59.7	32.8	•
75-8A	CG	123-137	130	14	7.0	•	•	•	•
75-8B	CG	137-152	145	15	7.4	1.7	64.4	33.9	•

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
75-1	A11	0-15	31	1138	325	813	62	71	1.00000E-06
75-2	A12	15-28	18*	709	287	422	73	60	6.30000E-07
75-3	A13	28-38	7	631	225	406	71	64	4.00000E-07
75-4	B1	38-48	7*	485	175	310	87	64	3.20000E-07
75-5	B21	48-61	7	390	150	240	92	62	2.50000E-07
75-6A	B22	61-76	6*	375	112	263	46	70	1.60000E-07
75-6B	B22	76-94	6*	336	100	236	38	70	1.60000E-07
75-7A	BC	94-107	5	358	200	158	32	44	1.00000E-07
75-7B	BC	107-123	6*	377	267	110	•	29	1.00000E-07
75-8A	CG	123-137	8*	370	267	103	•	28	1.00000E-07
75-8B	CG	137-152	9	396	288	108	•	27	4.00000E-08

Soil 75

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
75-1	A11	0-15	6.1	6.6	15	118	7.90000E-07	2.50000E-07
75-2	A12	15-28	6.3	6.8	8	27	5.00000E-07	1.60000E-07
75-3	A13	28-38	6.5	6.8	9	29	3.20000E-07	1.60000E-07
75-4	B1	38-48	6.6	7.1	5	17	2.50000E-07	7.90000E-08
75-5	B21	48-61	6.6	7.0	6	21	2.50000E-07	1.00000E-07
75-6A	B22	61-76	6.7	7.2	6	20	2.00000E-07	6.30000E-08
75-6B	B22	76-94	6.8	7.3	5	18	1.60000E-07	5.00000E-08
75-7A	BC	94-107	7.0	7.4	6	16	1.00000E-07	4.00000E-08
75-7B	BC	107-123	7.1	7.4	7	25	7.90000E-08	4.00000E-08
75-8A	CG	123-137	7.7	7.5	6	27	2.00000E-08	3.20000E-08
75-8B	CG	137-152	7.6	7.5	9	31	2.50000E-08	3.20000E-08

Soil 79

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
79-1	AP	0-18	9	18	5.8	17.8	54.8	27.4	3.1
79-2	A12	18-38	28	20	5.9	.	.	.	2.2
79-3	A13	38-52	45	14	6.3	8.8	56.5	34.7	1.2
79-4	B1	52-66	59	14	6.5	.	.	.	1.0
79-5	B21	66-87	77	21	6.5	12.9	55.4	31.7	0.8
79-6A	B22G	87-103	95	16	6.7	.	.	.	.
79-6B	B22G	103-119	110	16	6.7	17.6	52.9	29.5	.
79-7A	2C1G	119-134	127	15	6.5	25.4	46.8	27.8	.
79-7B	2C1G	134-152	143	18	6.5	22.0	48.6	29.4	.
79-8	2C2G	152-165	159	13	6.5	29.1	42.3	28.6	.
79-9	2C3G	165-178	172	13	6.5	28.7	35.5	25.8	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
79-1	AP	0-18	8	511	175	336	92	66	0.0000016
79-2	A12	18-38	5*	386	88	298	74	77	0.0000013
79-3	A13	38-52	2	370	75	295	41	80	5.00000E-07
79-4	B1	52-66	2*	206	75	131	76	64	3.20000E-07
79-5	B21	66-87	2*	205	75	130	51	63	3.20000E-07
79-6A	B22G	87-103	2	206	88	118	.	57	2.00000E-07
79-6B	B22G	103-119	4	261	150	111	.	43	2.00000E-07
79-7A	2C1G	119-134	5	317	225	92	.	29	3.20000E-07
79-7B	2C1G	134-152	6	338	200	138	.	41	3.20000E-07
79-8	2C2G	152-165	9	373	.	.	.	.	3.20000E-07
79-9	2C3G	165-178	6	452	363	89	.	20	3.20000E-07

Soil 81

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
81-1	AP	0-18	9	18	6.9	24.7	44.5	30.8	2.7
81-2A	A12	18-30	24	12	6.9	.	.	.	2.6
81-2B	A12	30-41	36	11	6.8	3.9	61.9	34.2	2.3
81-3	A13	41-51	46	10	6.5	.	.	.	2.3
81-4	B1	51-61	56	10	6.4	4.3	60.5	35.2	2.1
81-5	B21	61-76	69	15	6.4	.	.	.	2.3
81-6	B22	76-91	84	15	6.5	12.4	52.6	35.0	1.8
81-7A	B23	91-107	99	16	6.5	.	.	.	1.1
81-7B	B23	107-122	115	15	6.6	11.0	52.7	36.3	.
81-8A	B24	122-137	130	15	6.6	.	.	.	.
81-8B	B24	137-152	145	15	6.5	4.7	59.7	35.6	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
81-1	AP	0-18	57	653	413	240	113	37	1.30000E-07
81-2A	A12	18-30	39*	709	288	421	62	59	1.30000E-07
81-2B	A12	30-41	25*	563	225	338	68	60	1.60000E-07
81-3	A13	41-51	9	525	200	325	71	62	3.20000E-07
81-4	B1	51-61	10*	466	188	278	76	60	4.00000E-07
81-5	B21	61-76	10*	448	163	285	81	64	4.00000E-07
81-6	B22	76-91	10	413	138	275	65	67	3.20000E-07
81-7A	B23	91-107	11*	410	200	210	52	51	3.20000E-07
81-7B	B23	107-122	11*	373	200	173	.	46	2.50000E-07
81-8A	B24	122-137	12	375	188	187	.	50	2.50000E-07
81-8B	B24	137-152	.	375	275	100	.	27	3.20000E-07

Soil 81

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
81-1	AP	0-18	7.5	7.3	49	87	3.20000E-08	5.00000E-08
81-2A	A12	18-30	7.5	7.3	16	28	3.20000E-08	3.20000E-08
81-2B	A12	30-41	7.4	7.2	11	25	4.00000E-08	6.30000E-08
81-3	A13	41-51	7.0	7.1	10	21	1.00000E-07	7.90000E-08
81-4	B1	51-61	6.9	7.1	10	20	1.00000E-07	7.90000E-08
81-5	B21	61-76	6.9	7.0	12	20	1.30000E-07	1.00000E-07
81-6	B22	76-91	6.7	7.0	12	21	2.00000E-07	1.00000E-07
81-7A	B23	91-107	6.7	7.1	12	21	2.00000E-07	7.90000E-08
81-7B	B23	107-122	6.7	7.1	12	24	2.00000E-07	7.90000E-08
81-8A	B24	122-137	6.8	7.3	10	18	1.60000E-07	5.00000E-08
81-8B	B24	137-152	6.5	7.2	15	23	3.20000E-07	6.30000E-08

Soil 86

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
86-1A	AP	0-10	5	10	5.7	9.1	59.3	31.6	2.8
86-1B	AP	10-20	15	10	5.7	9.3	59.7	31.0	2.7
86-2	A12	20-36	28	16	5.7	7.6	59.9	32.5	2.5
86-3A	A13	36-47	42	11	5.7	7.8	59.8	32.4	1.5
86-3B	A13	47-58	53	11	5.7	7.5	60.2	32.3	1.2
86-4A	A14	58-71	65	13	5.9	8.2	58.5	33.3	1.1
86-4B	A14	71-84	78	13	5.9	7.7	58.6	33.7	1.0
86-5	B21	84-99	92	15	6.0	8.5	57.4	34.1	0.7
86-6	B22	99-114	107	15	6.0	.	.	.	0.8
86-7	B3G	114-130	124	16	6.0	19.6	51.8	28.6	.
86-8	CG	130-152	141	22	6.0	20.9	52.9	26.2	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION	TK
86-1A	AP	0-10	27	750	338	412	68	55	0.000002	1.1
86-1B	AP	10-20	11	697	300	397	68	57	0.000002	.
86-2	A12	20-36	9*	457	150	307	81	67	0.000002	0.9
86-3A	A13	36-47	8	320	100	220	68	69	0.000002	.
86-3B	A13	47-58	11*	302	125	177	68	59	0.000002	.
86-4A	A14	58-71	15*	302	200	102	108	34	0.0000013	1.0
86-4B	A14	71-84	19	413	325	88	114	21	0.0000013	.
86-5	B21	84-99	34*	446	438	8	.	.	1.00000E-07	1.0
86-6	B22	99-114	49	517	450	67	119	13	1.00000E-07	.
86-7	B3G	114-130	66*	644	625	19	.	3	1.00000E-07	1.2
86-8	CG	130-152	81	923	800	123	.	13	1.00000E-07	.

Soil 86

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
86-1A	AP	0-10	6.2	6.5	25	71	6.30000E-07	3.20000E-07
86-1B	AP	10-20	6.3	6.6	21	46	5.00000E-07	2.50000E-07
86-2	A12	20-36	5.9	6.5	7	24	0.0000013	3.20000E-07
86-3A	A13	36-47	6.1	6.6	8	21	7.90000E-07	2.50000E-07
86-3B	A13	47-58	5.9	6.7	6	15	0.0000013	2.00000E-07
86-4A	A14	58-71	6.4	7.1	8	14	4.00000E-07	7.90000E-08
86-4B	A14	71-84	6.3	7.0	13	16	5.00000E-07	1.00000E-07
86-5	B21	84-99	6.5	7.1	19	15	3.20000E-07	7.90000E-08
86-6	B22	99-114	6.3	7.0	37	19	5.00000E-07	1.00000E-07
86-7	B3G	114-130	6.5	7.2	37	16	3.20000E-07	6.30000E-08
86-8	CG	130-152	6.7	7.3	41	14	2.00000E-07	5.00000E-08

Soil 88

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
88-1	AP	0-20	10	20	6.1	5.1	63.6	31.3	1.9
88-2A	A12	20-33	27	13	5.9	.	.	.	1.4
88-2B	A12	33-46	40	13	5.6	4.6	59.7	35.7	1.2
88-3A	A13	46-58	52	12	5.6	.	.	.	0.9
88-3B	A13	58-69	64	11	5.7	5.1	55.0	39.9	0.8
88-4A	A14	69-81	75	12	5.6	.	.	.	0.6
88-4B	A14	81-91	86	10	5.7	6.0	55.2	38.8	0.5
88-5	A15	91-107	99	16	5.8	.	.	.	0.6
88-6	B2	107-123	115	16	5.9	5.3	55.7	39.0	.
88-7	B3	123-137	130	14	5.9	.	.	.	.
88-8	CG	137-152	145	15	6.0	6.2	57.3	36.5	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HICN	TK
88-1	AP	0-20	39	600	225	425	45	71	7.90000E-07	1.6
88-2A	A12	20-33	24*	464	125	339	41	73	0.0000013	.
88-2B	A12	33-46	14	373	88	285	42	76	0.0000025	.
88-3A	A13	46-58	20*	373	150	223	40	60	0.0000025	.
88-3B	A13	58-69	25	406	275	131	61	32	1.00000E-06	1.3
88-4A	A14	69-81	29*	446	288	158	38	35	0.0000025	.
88-4B	A14	81-91	33	431	325	106	47	25	0.000002	.
88-5	A15	91-107	34	448	300	148	41	33	0.0000016	.
88-6	B2	107-123	39	466	363	103	.	22	0.0000013	.
88-7	B3	123-137	41*	525	413	112	.	21	0.0000013	.
88-8	CG	137-152	44	525	413	112	.	21	1.00000E-07	1.4

Soil 88

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
88-1	AP	0-20	6.5	6.8	30	125	3.20000E-07	1.60000E-07
88-2A	A12	20-33	6.1	6.7	11	35	7.90000E-07	2.00000E-07
88-2B	A12	33-46	6.0	6.6	9	28	1.00000E-06	2.50000E-07
88-3A	A13	46-58	5.8	6.5	9	23	0.0000016	3.20000E-07
88-3B	A13	58-69	6.0	6.9	15	23	1.00000E-06	1.30000E-07
88-4A	A14	69-81	6.2	7.1	19	20	6.30000E-07	7.90000E-08
88-4B	A14	81-91	6.4	7.3	17	19	4.00000E-07	5.00000E-08
88-5	A15	91-107	6.2	7.0	25	22	6.30000E-07	1.00000E-07
88-6	B2	107-123	6.4	7.3	20	19	4.00000E-07	5.00000E-08
88-7	B3	123-137	6.3	7.1	25	23	5.00000E-07	7.90000E-08
88-8	CG	137-152	6.4	7.1	26	22	4.00000E-07	7.90000E-08

Soil 95

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
95-1A	A11	0-5	3	5	7.3	10.0	50.6	39.4	3.6
95-2A	A12	15-20	18	5	7.1	13.3	51.2	35.5	3.5
95-2D	A12	30-35	33	5	7.2	15.0	49.6	35.4	2.2
95-2F	A12	45-50	48	5	7.1	18.5	48.1	33.4	2.3
95-2I	A12	60-66	63	6	7.0	23.3	43.6	33.1	1.8
95-3C	A13	76-81	79	5	7.0	25.5	42.5	32.0	1.4
95-3F	A13	91-96	94	5	7.0	22.8	44.2	33.0	1.7
95-4B	A14	112-119	117	7	7.0	24.5	43.2	32.3	.
95-5B	C	135-152	142	17	7.2	41.4	33.8	24.8	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION	TK
95-1A	A11	0-5	51	1131	600	581	62	49	5.00000E-08	0.7
95-2A	A12	15-20	6	694	400	294	119	42	7.90000E-08	0.9
95-2D	A12	30-35	7	606	400	202	109	33	6.30000E-08	.
95-2F	A12	45-50	7	464	313	151	152	33	7.90000E-08	0.7
95-2I	A12	60-66	11	375	275	100	180	27	1.00000E-08	0.9
95-3C	A13	76-81	16	469	375	94	149	20	1.00000E-08	.
95-3F	A13	91-96	29	662	575	87	195	13	1.00000E-08	1.2
95-4B	A14	112-119	24	628	550	78	.	12	1.00000E-08	.
95-5B	C	135-152	37	914	850	64	.	7	6.30000E-08	.

Soil 95

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
95-1A	A11	0-5	7.4	7.3	56	62	4.00000E-08	5.00000E-08
95-2A	A12	15-20	7.9	7.4	6	11	1.30000E-08	4.00000E-08
95-2D	A12	30-35	7.8	7.4	7	11	1.60000E-08	4.00000E-08
95-2F	A12	45-50	7.7	7.4	6	11	2.00000E-08	4.00000E-08
95-2I	A12	60-66	7.5	7.4	8	14	3.20000E-08	4.00000E-08
95-3C	A13	76-81	7.6	7.4	12	15	2.50000E-08	4.00000E-08
95-3F	A13	91-96	7.6	7.4	17	14	2.50000E-08	4.00000E-08
95-4B	A14	112-119	7.5	7.4	15	15	3.20000E-08	4.00000E-08
95-5B	C	135-152	7.4	7.4	34	28	4.00000E-08	4.00000E-08

Soil 96-1

SOIL	HORIZON	DEPTH CM	MDPT CM	%GTPT	PH	SAND	SILT	CLAY	TC
96-1A	A11	0-10	5	10	7.4	4.2	69.0	26.8	3.9
96-1B	A11	10-20	15	10	7.6	.	.	.	4.1
96-2	A12	20-36	28	16	7.5	.	.	.	3.6
96-3	A13	36-48	42	12	7.3	5.9	63.6	30.5	3.2
96-4A	A14	48-56	52	8	7.1	.	.	.	2.9
96-4B	A14	56-66	61	10	7.3	.	.	.	2.9
96-5A	A15	66-76	71	10	7.4	6.2	62.8	31.0	3.1
96-5B	A15	76-86	81	10	7.3	.	.	.	3.0
96-6	A16	86-99	93	13	7.3	5.9	63.2	30.9	2.9
96-7	AC	99-112	106	13	7.5	.	.	.	2.3
96-8	C1	112-130	123	18	7.1	.	.	.	.
96-9	C2	130-152	141	22	6.6	10.3	62.5	27.2	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	CC/OP	OP/TP	HION
96-1A	A11	0-10	4	802	300	502	78	63	4.00000E-08
96-1B	A11	10-20	3	746	300	446	92	60	2.50000E-08
96-2	A12	20-36	3	989	325	664	54	67	3.20000E-08
96-3	A13	36-48	4	1005	313	692	46	69	5.00000E-08
96-4A	A14	48-56	5	1045	250	795	36	76	7.90000E-08
96-4B	A14	56-66	4	746	250	496	58	66	5.00000E-08
96-5A	A15	66-76	5	780	250	530	58	68	4.00000E-08
96-5B	A15	76-86	5	742	250	492	61	66	5.00000E-08
96-6	A16	86-99	6	687	238	449	65	65	5.00000E-08
96-7	AC	99-112	4	573	243	330	70	58	5.00000E-08
96-8	C1	112-130	6	573	250	323	.	56	3.20000E-08
96-9	C2	130-152	10	483	225	233	.	48	2.50000E-07

Soil 96-2

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
96-1A	AP	0-8	4	8	7.4	10.1	50.9	39.0	4.3
96-1B	AP	8-18	13	10	7.4	.	.	.	3.6
96-2	A12	18-30	24	12	7.3	.	.	.	3.7
96-3A	A13	30-41	36	11	7.2	7.9	51.6	40.5	3.2
96-3B	A13	41-51	46	10	7.2	.	.	.	3.2
96-4A	A14	51-58	55	7	7.0	.	.	.	2.7
96-4B	A14	58-69	64	11	7.0	.	.	.	2.6
96-5A	A15	69-81	75	12	7.0	12.4	48.9	38.7	3.0
96-5B	A15	81-91	36	10	6.9	.	.	.	1.9
96-6	A16	91-104	98	13	6.7	.	.	.	1.8
96-7A	A17	104-117	111	13	6.7	.	.	.	.
96-7B	A17	117-130	124	13	6.7	.	.	.	.
96-8	C	130-152	141	22	6.8	21.4	43.7	34.9	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
96-1A	AP	0-8	23	1028	400	628	68	61	4.00000E-08
96-1B	AP	8-18	19*	1005	375	630	57	63	4.00000E-08
96-2	A12	18-30	15*	933	288	645	57	69	5.00000E-08
96-3A	A13	30-41	10	891	300	591	54	66	6.30000E-08
96-3B	A13	41-51	11*	900	325	575	56	64	6.30000E-08
96-4A	A14	51-58	14*	806	338	468	58	58	1.00000E-07
96-4B	A14	58-69	14*	732	363	369	70	50	1.00000E-07
96-5A	A15	69-81	15	850	400	450	67	53	1.00000E-07
96-5B	A15	81-91	18*	881	550	331	57	38	1.30000E-07
96-6	A16	91-104	21*	867	600	267	67	31	2.00000E-07
96-7A	A17	104-117	26*	821	513	308	.	38	2.00000E-07
96-7B	A17	117-130	30*	754	550	204	.	27	2.00000E-07
96-8	C	130-152	37	821	650	171	.	21	1.60000E-07

Soil 97

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
97-1	AP	0-20	10	20	5.6	1.8	64.1	34.1	2.1
97-2	A12	20-36	28	16	6.2	.	.	.	2.4
97-3	A13	36-51	44	15	6.4	3.5	61.5	35.0	2.4
97-4	A14	51-71	61	20	6.7	.	.	.	2.3
97-5	A15	71-91	81	20	6.7	3.2	61.0	35.8	2.2
97-6	A16	91-123	109	32	6.7	.	.	.	1.1
97-7	AC	123-140	132	17	6.6	.	.	.	.
97-8	C	140-152	146	12	6.5	5.4	60.6	34.0	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	CC/OP	OP/TP	HION
97-1	AP	0-20	80	863	525	338	62	39	0.0000032
97-2	A12	20-36	57*	825	450	375	64	45	0.0000063
97-3	A13	36-51	37	825	463	362	66	44	0.000004
97-4	A14	51-71	34*	713	413	300	77	42	0.000002
97-5	A15	71-91	31	709	413	296	77	42	0.000002
97-6	A16	91-123	30*	578	450	128	86	79	0.000002
97-7	AC	123-140	29*	562	437	125	.	22	0.0000025
97-8	C	140-152	28	578	450	128	.	22	0.0000032

Soil 97

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
97-1	AP	0-20	6.1	6.8	55	240	7.90000E-07	1.60000E-07
97-2	A12	20-36	6.9	7.1	31	100	1.30000E-07	7.90000E-08
97-3	A13	36-51	7.0	7.1	28	54	1.00000E-07	7.90000E-08
97-4	A14	51-71	6.8	7.0	24	74	1.60000E-07	1.00000E-07
97-5	A15	71-91	6.8	7.0	25	72	1.60000E-07	1.00000E-07
97-6	A16	91-123	6.9	7.2	21	63	1.30000E-07	6.30000E-08
97-7	AC	123-140	6.9	7.4	23	23	1.30000E-07	4.00000E-08
97-8	C	140-152	6.9	7.3	24	42	1.30000E-07	5.00000E-08

Soil N1

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
N1-1	AP	0-18	9	18	6.8	3.9	57.3	38.8	1.9
N1-2	A12	18-33	26	15	6.5	.	.	.	1.7
N1-3A	A13	33-46	40	13	6.7	6.4	58.8	34.8	2.5
N1-3B	A13	46-56	51	10	6.8	.	.	.	2.3
N1-4	A14	56-66	61	10	7.2	.	.	.	2.1
N1-5	A15	66-79	73	13	7.4	4.4	60.8	34.8	1.6
N1-6	B1	79-97	88	18	7.5	.	.	.	1.1
N1-7	B2	97-109	103	12	7.4	.	.	.	0.7
N1-8	BC	109-123	115	14	7.6	4.8	62.4	32.8	.
N1-9A	CG	123-137	130	14	7.5	.	.	.	.
N1-9B	CG	137-152	145	15	7.4	6.0	62.6	31.4	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
N1-1	AP	0-18	6	591	300	291	65	49	1.60000E-07
N1-2	A12	18-33	8	594	275	319	53	54	3.20000E-07
N1-3A	A13	33-46	6	563	275	288	87	51	2.00000E-07
N1-3B	A13	46-56	5	564	250	314	73	56	1.60000E-07
N1-4	A14	56-66	6	522	250	272	77	52	6.30000E-08
N1-5	A15	66-79	5	428	238	190	84	44	4.00000E-08
N1-6	B1	79-97	4	410	138	272	40	66	3.20000E-08
N1-7	B2	97-109	3	383	175	208	34	54	4.00000E-08
N1-8	BC	109-123	4	362	250	112	.	31	2.50000E-08
N1-9A	CG	123-137	11	371	250	121	.	33	3.20000E-08
N1-9B	CG	137-152	17	419	313	106	.	25	4.00000E-08

Soil N2

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
N2-1	AP	0-18	9	18	6.0	3.3	64.2	32.5	2.0
N2-2	A12	18-28	23	10	5.7	4.1	64.9	31.0	1.8
N2-3A	A13	28-38	33	10	5.7	5.3	64.0	30.7	1.6
N2-3B	A13	38-48	43	10	5.7	3.9	65.7	30.4	1.1
N2-4A	A14	48-66	57	18	6.0	3.8	65.8	30.4	1.1
N2-4B	A14	66-79	73	13	5.9	4.9	64.4	30.7	1.1
N2-5A	A15	79-94	87	15	6.3	6.5	64.3	29.2	1.0
N2-5B	A15	94-109	102	15	6.5	5.1	65.2	29.7	1.3
N2-6	A16	109-132	121	23	6.8	6.4	62.8	30.8	1.7
N2-7	A17	132-152	142	20	6.9	6.9	63.3	29.8	1.3

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION	TK
N2-1	AP	0-18	37	739	400	339	59	46	1.00000E-06	.
N2-2	A12	18-28	20	684	363	321	56	47	0.000002	1.4
N2-3A	A13	28-38	25	628	375	253	63	40	0.000002	.
N2-3B	A13	38-48	29	568	388	180	61	32	0.000002	0.7
N2-4A	A14	48-66	39	600	425	175	63	29	1.00000E-06	0.6
N2-4B	A14	66-79	40	600	450	150	73	25	0.0000013	.
N2-5A	A15	79-94	51	675	450	225	44	33	0.000005	.
N2-5B	A15	94-109	60	918	738	180	72	20	0.0000032	.
N2-6	A16	109-132	58	810	675	135	126	17	0.0000016	0.6
N2-7	A17	132-152	54	739	625	114	114	18	0.0000013	.

Soil N2

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
N2-1	AP	0-18	6.1	6.6	31	130	7.90000E-07	2.50000E-07
N2-2	A12	18-28	5.9	6.4	22	52	0.0000013	4.00000E-07
N2-3A	A13	28-38	6.0	6.6	27	45	1.00000E-06	2.50000E-07
N2-3B	A13	38-48	5.9	6.7	34	36	0.0000013	2.00000E-07
N2-4A	A14	48-66	6.1	6.8	34	36	7.90000E-07	1.60000E-07
N2-4B	A14	66-79	6.3	6.9	44	42	5.00000E-07	1.30000E-07
N2-5A	A15	79-94	6.4	7.0	49	33	4.00000E-07	1.00000E-07
N2-5B	A15	94-109	6.8	7.2	58	37	1.60000E-07	6.30000E-08
N2-6	A16	109-132	7.1	7.3	39	44	7.90000E-08	5.00000E-08
N2-7	A17	132-152	7.5	7.4	62	54	3.20000E-08	4.00000E-08

Soil N3

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
N3-1	AP	0-18	9	18	5.7	1.2	63.5	35.3	2.2
N3-2A	A12	18-33	26	15	6.2	.	.	.	2.3
N3-2B	A12	33-48	41	15	6.4	1.0	59.2	39.8	1.2
N3-3A	A13	48-64	56	16	6.5	.	.	.	0.9
N3-3B	A13	64-79	72	15	6.6	.	.	.	0.6
N3-3C	A13	79-94	87	15	6.6	1.4	63.5	35.1	0.6
N3-4A	B	94-109	102	15	6.7	.	.	.	0.5
N3-4B	B	109-124	117	15	6.7	1.4	62.4	36.2	.
N3-4C	B	124-140	132	16	6.7	.	.	.	.
N3-5	CG	140-152	146	12	6.7	1.4	60.7	37.9	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
N3-1	AP	0-18	72	678	425	253	87	37	0.000002
N3-2A	A12	18-33	36	634	350	284	81	45	6.30000E-07
N3-2B	A12	33-48	34	609	450	159	75	26	4.00000E-07
N3-3A	A13	48-64	35	597	463	134	67	22	3.20000E-07
N3-3B	A13	64-79	37	570	500	70	86	12	2.50000E-07
N3-3C	A13	79-94	31	603	475	128	47	21	2.50000E-07
N3-4A	B	94-109	32	490	413	77	65	16	2.00000E-07
N3-4B	B	109-124	34	452	375	77	.	17	2.00000E-07
N3-4C	B	124-140	36	479	400	79	.	16	2.00000E-07
N3-5	CG	140-152	38	512	438	74	.	14	2.00000E-07

Soil N4

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
N4-1	AP	0-18	9	18	6.0	5.4	66.2	28.4	1.2
N4-2	A12	18-25	22	7	6.1	.	.	.	1.4
N4-3	B1	25-38	32	13	5.7	4.3	62.6	33.1	1.6
N4-4A	B21	38-53	46	15	5.7	.	.	.	1.9
N4-4B	B21	53-71	62	18	5.8	.	.	.	1.5
N4-5	B22	71-89	80	18	5.9	5.5	60.9	33.6	1.0
N4-6	B3G	89-112	101	23	6.2	.	.	.	0.6
N4-7	C1G	112-127	120	15	6.4	.	.	.	.
N4-8	C2G	127-152	140	25	6.5	9.1	67.3	23.6	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
N4-1	AP	0-18	67	563	425	138	87	25	1.00000E-06
N4-2	A12	18-25	71	610	413	197	71	32	7.90000E-07
N4-3	B1	25-38	88	699	463	236	68	34	0.000002
N4-4A	B21	38-53	77	663	375	288	66	43	0.000002
N4-4B	B21	53-71	47	516	300	216	69	42	0.0000016
N4-5	B22	71-89	43	538	400	138	72	26	0.0000013
N4-6	B3G	89-112	45	439	413	26	231	6	6.30000E-07
N4-7	C1G	112-127	42	413	350	63	.	15	4.00000E-07
N4-8	C2G	127-152	58	483	450	33	.	7	3.20000E-07

Soil M1

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
M1-1	AP	0-18	9	18	6.5	16.5	55.2	28.3	1.8
M1-2	A12	18-33	26	15	6.7	15.9	55.6	28.5	1.8
M1-3	A3	33-43	38	10	6.5	14.2	56.7	29.2	1.5
M1-4A	B21	43-56	50	13	6.4	16.8	54.7	28.5	1.3
M1-4B	B21	56-69	63	13	6.4	19.0	53.2	27.8	1.1
M1-5	B22	69-86	78	17	6.5	21.3	51.5	27.4	0.8
M1-6	B23	86-97	92	11	6.4	22.5	50.5	27.0	0.5
M1-7	B3	97-107	102	10	6.4	25.6	46.8	27.6	0.1
M1-8	C1	107-127	117	20	6.5	27.2	45.3	27.5	.
M1-9	C2G	127-140	134	13	6.5	33.6	40.1	26.3	.
M1-10	C3G	140-152	146	12	6.5	35.2	40.5	24.3	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
M1-1	AP	0-18	45	580	388	192	94	33	3.20000E-07
M1-2	A12	18-33	30	565	325	240	75	42	2.00000E-07
M1-3	A3	33-43	4	494	225	269	56	54	3.20000E-07
M1-4A	B21	43-56	7	413	125	288	45	70	4.00000E-07
M1-4B	B21	56-69	13	359	163	196	56	55	4.00000E-07
M1-5	B22	69-86	16	325	163	162	49	50	3.20000E-07
M1-6	B23	86-97	15	319	175	144	35	45	4.00000E-07
M1-7	B3	97-107	22	319	175	144	7	45	4.00000E-07
M1-8	C1	107-127	26	318	225	93	.	29	3.20000E-07
M1-9	C2G	127-140	26	333	263	70	.	21	3.20000E-07
M1-10	C3G	140-152	28	397	300	97	.	24	3.20000E-07

Soil M2

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
M2-1	AP	0-10	5	10	5.6	0.7	64.2	35.1	1.0
M2-2	A12	10-20	15	10	5.6	0.7	64.2	35.0	0.9
M2-3	B21	20-33	27	13	5.5	1.0	54.2	44.8	0.8
M2-4	B22	33-43	38	10	5.7	1.5	59.3	39.2	1.0
M2-5	B23	43-61	52	18	5.9	2.0	60.1	37.9	1.3
M2-6A	B24	61-76	69	15	5.8	2.7	63.7	33.6	1.8
M2-6B	B24	76-89	83	13	5.7	2.5	64.7	32.8	1.2
M2-6C	B24	89-102	96	13	5.7	2.4	65.5	32.1	0.6
M2-7	B31G	102-123	113	21	5.8	2.5	66.2	31.3	.
M2-8	B32G	123-135	129	12	6.2	2.9	66.7	30.4	.
M2-9	B33G	135-152	144	17	6.4	3.2	65.4	31.4	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
M2-1	AP	0-10	47	641	425	216	46	34	0.0000025
M2-2	A12	10-20	35	619	338	281	32	45	0.0000025
M2-3	B21	20-33	17	619	200	419	19	68	0.0000032
M2-4	B22	33-43	25	619	300	319	31	52	0.000002
M2-5	B23	43-61	30	672	400	272	48	40	0.0000013
M2-6A	B24	61-76	27	675	325	350	51	52	0.0000016
M2-6B	B24	76-89	20	455	225	230	52	51	0.000002
M2-6C	B24	89-102	26	525	225	300	20	57	0.000002
M2-7	B31G	102-123	20	392	200	192	.	49	0.0000016
M2-8	B32G	123-135	23	334	200	134	.	40	6.30000E-07
M2-9	B33G	135-152	19	417	250	167	.	40	4.00000E-07

Soil M3

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
M3-1	AP	0-18	9	18	6.8	2.2	73.1	24.7	1.5
M3-2	A12	18-33	26	15	7.0	2.3	70.5	27.2	1.4
M3-3	B1	33-46	40	13	6.4	3.3	68.2	28.5	1.2
M3-4	B21	46-61	54	15	6.0	3.4	65.2	31.4	1.1
M3-5A	B22	61-74	68	13	5.7	3.4	61.2	35.4	0.8
M3-5B	B22	74-86	80	12	6.1	3.4	59.6	37.0	0.8
M3-6A	B23	86-104	95	18	6.0	2.9	60.2	36.9	0.7
M3-6B	B23	104-122	113	18	6.1	3.1	60.4	36.5	0.7
M3-7A	B3G	122-137	130	15	6.5	2.4	58.0	39.6	.
M3-7B	B3G	137-152	145	15	6.5	3.0	59.1	37.9	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION	TK
M3-1	AP	0-18	70	622	400	222	68	36	1.60000E-07	1.4
M3-2	A12	18-33	59	602	388	214	65	36	1.00000E-07	.
M3-3	B1	33-46	24	599	225	374	32	62	4.00000E-07	1.4
M3-4	B21	46-61	20	451	250	201	55	45	1.00000E-06	.
M3-5A	B22	61-74	28	408	275	133	60	33	0.000002	.
M3-5B	B22	74-86	32	450	288	162	49	36	7.90000E-07	.
M3-6A	B23	86-104	36	409	288	121	58	30	1.00000E-06	.
M3-6B	B23	104-122	33	480	288	192	36	40	7.90000E-07	1.4
M3-7A	B3G	122-137	42	446	325	121	.	27	3.20000E-07	.
M3-7B	B3G	137-152	.	404	325	79	.	20	3.20000E-07	1.5

Soil M3

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
M3-1	AP	0-18	7.2	7.2	70	104	6.30000E-08	6.30000E-08
M3-2	A12	18-33	7.1	7.1	29	31	7.90000E-08	7.90000E-08
M3-3	B1	33-46	6.7	6.9	14	22	2.00000E-07	1.30000E-07
M3-4	B21	46-61	6.2	6.7	16	21	6.30000E-07	2.00000E-07
M3-5A	B22	61-74	6.3	6.9	14	20	5.00000E-07	1.30000E-07
M3-5B	B22	74-86	6.2	7.1	15	15	6.30000E-07	7.90000E-08
M3-6A	B23	86-104	6.5	7.4	14	13	3.20000E-07	4.00000E-08
M3-6B	B23	104-122	6.9	7.5	13	11	1.30000E-07	3.20000E-08
M3-7A	B3G	122-137	6.9	7.5	15	14	1.30000E-07	3.20000E-08
M3-7B	B3G	137-152	7.0	7.5	15	14	1.00000E-07	3.20000E-08

Soil M4

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
M4-1	AP	0-20	10	20	6.8	1.2	67.4	31.4	2.0
M4-2	A12	20-36	28	16	6.7	1.0	63.9	35.1	1.7
M4-3A	B21	36-51	44	15	5.8	0.9	60.2	38.9	1.4
M4-3B	B21	51-66	59	15	5.7	1.0	62.1	36.9	1.2
M4-4A	B22	66-79	73	13	5.8	1.1	64.3	34.6	1.0
M4-4B	B22	79-91	85	12	5.9	8.8	57.8	33.4	0.9
M4-5	B23	91-102	97	11	5.9	3.9	62.8	33.3	0.6
M4-6	B24	102-123	113	21	6.0	4.6	59.9	35.5	.
M4-7	B25	123-137	130	14	6.2	4.3	59.5	36.2	.
M4-8	B3G	137-152	145	15	6.3	4.0	57.6	38.4	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
M4-1	AP	0-20	19	478	263	215	93	45	1.60000E-07
M4-2	A12	20-36	10*	372	163	209	81	57	2.00000E-07
M4-3A	B21	36-51	2	299	113	186	75	62	0.0000016
M4-3B	B21	51-66	2*	262	75	187	64	71	0.000002
M4-4A	B22	66-79	3	224	100	124	81	55	0.0000016
M4-4B	B22	79-91	4*	261	100	161	56	62	0.0000013
M4-5	B23	91-102	6	277	175	102	59	37	0.0000013
M4-6	B24	102-123	7*	340	238	102	.	30	1.00000E-06
M4-7	B25	123-137	9	366	275	91	.	25	6.30000E-07
M4-8	B3G	137-152	.	342	150	192	.	56	5.00000E-07

Soil M4

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
M4-1	AP	0-20	7.2	7.2	18	57	6.30000E-08	6.30000E-08
M4-2	A12	20-36	6.5	6.8	7	22	3.20000E-07	1.60000E-07
M4-3A	B21	36-51	6.0	6.6	7	18	1.00000E-06	2.50000E-07
M4-3B	B21	51-66	6.0	6.7	6	18	1.00000E-06	2.00000E-07
M4-4A	B22	66-79	6.0	6.7	7	19	1.00000E-06	2.00000E-07
M4-4B	B22	79-91	6.1	6.9	8	21	7.90000E-07	1.30000E-07
M4-5	B23	91-102	6.2	7.0	7	25	6.30000E-07	1.00000E-07
M4-6	B24	102-123	6.3	7.1	8	23	5.00000E-07	7.90000E-08
M4-7	B25	123-137	6.7	7.3	11	20	2.00000E-07	5.00000E-08
M4-8	B3G	137-152	6.8	7.4	12	20	1.60000E-07	4.00000E-08

Soil I

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
I-1	AP	0-18	9	18	6.4	1.6	70.6	27.8	2.4
I-2	A12	18-30	24	12	6.8	4.3	62.1	33.6	2.5
I-3A	B21	30-46	38	16	6.9	8.8	57.7	33.5	2.3
I-3B	B21	46-58	52	12	6.9	19.6	52.0	28.6	2.2
I-4	B22	58-79	69	21	6.9	26.5	45.9	27.6	1.8
I-5	B31	79-97	88	18	6.8	26.6	45.7	27.7	1.3
I-6	B32G	97-123	110	26	6.8	26.0	46.8	27.2	.

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
I-1	AP	0-18	26	606	325	281	85	46	4.00000E-07
I-2	A12	18-30	13	716	325	391	64	55	1.60000E-07
I-3A	B21	30-46	10	754	.	.	.	.	1.30000E-07
I-3B	B21	46-58	8	930	300	630	34	68	1.30000E-07
I-4	B22	58-79	7	647	288	359	50	55	1.30000E-07
I-5	B31	79-97	5	603	.	.	.	.	1.60000E-07
I-6	B32G	97-123	5	452	150	302	.	67	1.60000E-07

Soil I2

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
I2-1A	A11	0-13	7	13	7.0	12.4	58.8	28.8	1.7
I2-1B	A11	13-23	18	10	6.9	19.8	53.4	26.8	1.7
I2-2A	A12	23-38	31	15	6.8	16.4	55.7	27.9	1.8
I2-2B	A12	38-51	45	13	6.7	21.0	51.9	27.1	1.8
I2-2C	A12	51-58	55	7	6.7	23.0	51.4	25.6	1.4
I2-3A	A13	58-74	66	16	6.5	15.7	56.2	28.1	1.1
I2-3B	A13	74-88	82	16	6.4	16.9	56.0	27.1	0.9
I2-4	B	88-100	95	12	6.6	17.2	55.1	27.7	0.9

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HIUN	TK
I2-1A	A11	0-13	20	528	150	378	44	72	1.00000E-07	1.8
I2-1B	A11	13-23	8	522	238	284	60	54	1.30000E-07	1.8
I2-2A	A12	23-38	8	560	213	347	52	62	1.60000E-07	1.9
I2-2B	A12	38-51	4	525	163	362	50	69	2.00000E-07	1.7
I2-2C	A12	51-58	4	450	113	337	42	79	2.00000E-07	1.8
I2-3A	A13	58-74	3	412	88	324	34	79	3.20000E-07	1.8
I2-3B	A13	74-88	4	356	88	269	34	75	4.00000E-07	1.7
I2-4	B	88-100	3	240	75	165	54	69	2.50000E-07	1.6

Soil I2

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
I2-1A	A11	0-13	7.8	7.3	14	57	1.60000E-08	5.00000E-08
I2-1B	A11	13-23	7.7	7.3	14	57	1.60000E-08	5.00000E-08
I2-2A	A12	23-38	7.7	7.3	6	35	2.00000E-08	5.00000E-08
I2-2B	A12	38-51	7.8	7.3	4	21	1.60000E-08	5.00000E-08
I2-2C	A12	51-58	7.8	7.3	4	24	1.60000E-08	5.00000E-08
I2-3A	A13	58-74	7.8	7.2	3	26	1.60000E-08	6.30000E-08
I2-3B	A13	74-88	7.3	7.2	6	34	5.00000E-08	6.30000E-08
I2-4	B	88-100	7.4	7.3	4	28	4.00000E-08	5.00000E-08

Soil MINN1

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
MINN-1	AP	0-15	8	15	7.3	2.1	53.7	44.2	3.3
MINN-2	A12	15-28	22	13	7.3	1.9	52.2	45.9	3.4
MINN-3	A13	28-46	37	18	7.1	2.3	48.7	49.0	2.5
MINN-4	A14	46-76	61	30	7.0	3.3	47.2	49.5	1.6
MINN-5	A15	76-94	85	18	6.8	3.6	49.2	47.2	1.8
MINN-6	A16	94-114	104	20	6.9	3.7	46.4	49.9	1.5
MINN-7	A17	114-127	121	13	6.9	3.9	47.5	48.6	1.8
MINN-8	C1	127-140	134	13	6.8	6.2	46.5	47.3	1.4
MINN-9	C2	140-152	146	12	6.8	7.3	47.4	45.3	1.1

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HICN	TK
MINN-1	AP	0-15	40	769	450	319	103	41	5.00000E-08	0.9
MINN-2	A12	15-28	25*	754	375	379	90	50	5.00000E-08	.
MINN-3	A13	28-46	5	450	275	175	143	39	7.90000E-08	0.8
MINN-4	A14	46-76	6*	455	325	130	123	29	1.00000E-07	.
MINN-5	A15	76-94	17	560	325	235	77	42	1.60000E-07	.
MINN-6	A16	94-114	20	563	100	463	32	82	1.30000E-07	.
MINN-7	A17	114-127	22	452	288	164	110	36	1.30000E-07	.
MINN-8	C1	127-140	26	788	668	120	117	15	1.60000E-07	1.1
MINN-9	C2	140-152	32	886	525	361	30	41	1.60000E-07	.

Soil MINN1

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
MINN-1	AP	0-15	7.8	7.4	36	89	1.60000E-08	4.00000E-08
MINN-2	A12	15-28	7.8	7.4	24	47	1.60000E-08	4.00000E-08
MINN-3	A13	28-46	7.5	7.3	8	17	3.20000E-08	5.00000E-08
MINN-4	A14	46-76	7.5	7.4	6	12	3.20000E-08	4.00000F-08
MINN-5	A15	76-94	7.4	7.3	11	16	4.00000E-08	5.00000E-08
MINN-6	A16	94-114	7.2	7.3	12	16	6.30000E-08	5.00000E-08
MINN-7	A17	114-127	7.2	7.4	14	16	6.30000E-08	4.00000E-08
MINN-8	C1	127-140	7.3	7.4	18	15	6.30000E-08	4.00000E-08
MINN-9	C2	140-152	7.3	7.3	17	15	5.00000E-08	5.00000E-08

Soil MINN2

SOIL	HORIZON	DEPTH CM	MDPT CM	WGTPT	PH	SAND	SILT	CLAY	TC
MINN-1	A11	0-15	8	15	6.6	18.4	52.4	29.2	4.5
MINN-2	A12	15-38	27	23	6.8	19.6	51.7	28.7	2.1
MINN-3	A13	38-61	50	23	6.9	26.3	49.5	24.2	1.1
MINN-4	A14	61-76	69	15	6.9	27.3	47.2	25.5	0.8
MINN-5	A15	76-91	84	15	6.9	24.9	48.4	26.7	0.8
MINN-6A	CG	91-107	99	16	6.9	6.6	69.0	24.4	0.2
MINN-6B	CG	107-122	115	15	7.2	7.2	68.0	24.9	0.1

SOIL	HORIZON	DEPTH CM	AVP	TP	IP	OP	OC/OP	OP/TP	HION
MINN-1	A11	0-15	9	656	225	431	104	60	2.50000E-07
MINN-2	A12	15-38	9*	281	100	181	116	64	1.60000E-07
MINN-3	A13	38-61	9	188	113	76	145	65	1.30000E-07
MINN-4	A14	61-76	14*	264	200	64	125	24	1.30000E-07
MINN-5	A15	76-91	8	675	200	475	17	70	1.30000E-07
MINN-6A	CG	91-107	7*	675	485	190	11	28	1.30000E-07
MINN-6B	CG	107-122	7	672	537	135	7	20	7.90000E-08

Soil MINN2

SOIL	HORIZON	DEPTH CM	STPH	STBPH	STAVP	STAVK	STHION	STBHION
MINN-1	A11	0-15	7.2	7.2	9	33	6.30000E-08	6.30000E-08
MINN-2	A12	15-38	7.0	7.1	6	19	1.00000E-07	7.90000E-08
MINN-3	A13	38-61	7.3	7.4	7	19	5.00000E-08	4.00000E-08
MINN-4	A14	61-76	7.3	7.3	9	22	5.00000E-08	5.00000E-08
MINN-5	A15	76-91	7.4	7.4	7	16	4.00000E-08	4.00000E-08
MINN-6A	CG	91-107	.	.	.	.	.	.
MINN-6B	CG	107-122	.	.	.	.	.	.

APPENDIX C: X RAY DIFFRACTION PATTERNS

The following figures are computer printouts of the x-ray diffraction patterns on selected horizons of some Colo soils in the NCR. The abbreviations UNTREAT, MGCLEG, and HEATED means the sample untreated, treated with 10% $MgCl_2$ ethylene glycol, and heated to 300°C, respectively. Other information relative to how the clay minerals were determined is given in the text.

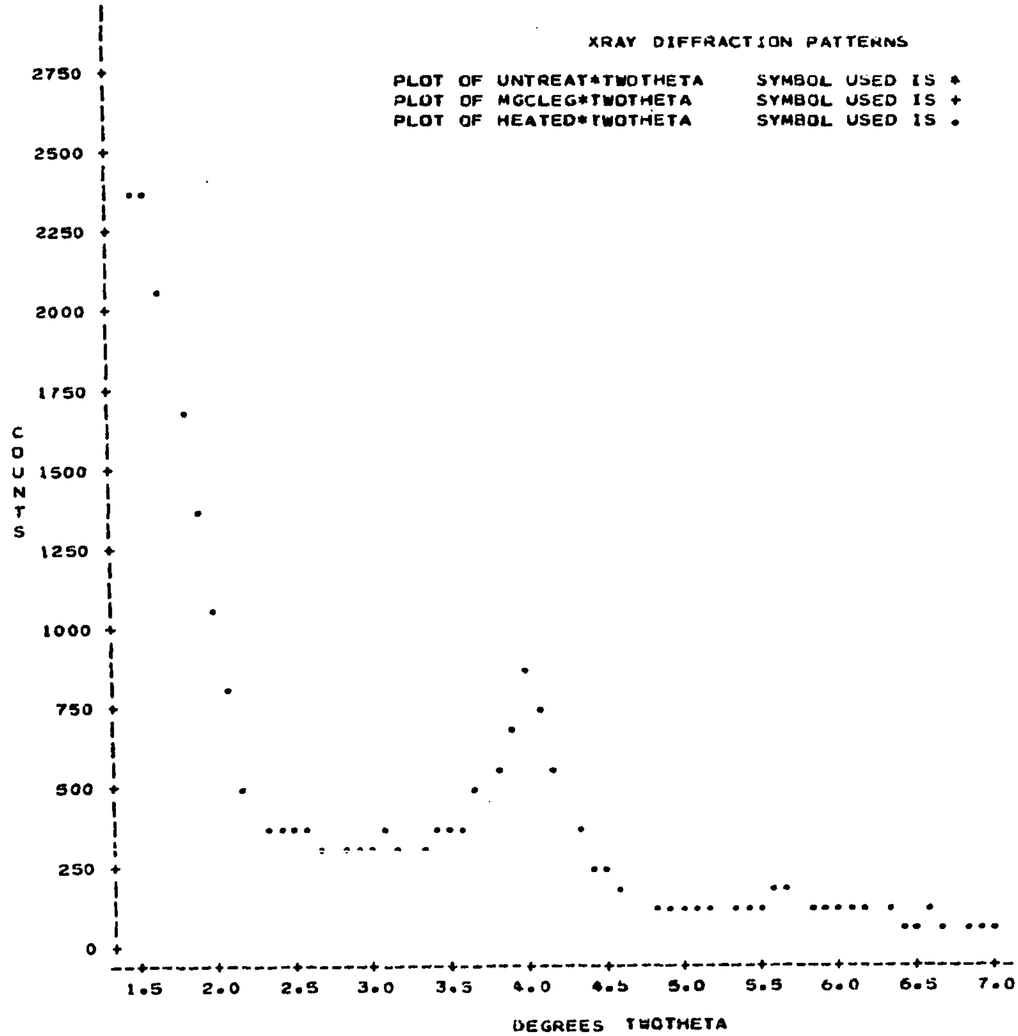

Figure 51. X-ray diffraction pattern for soil 21 (0-15 cm)

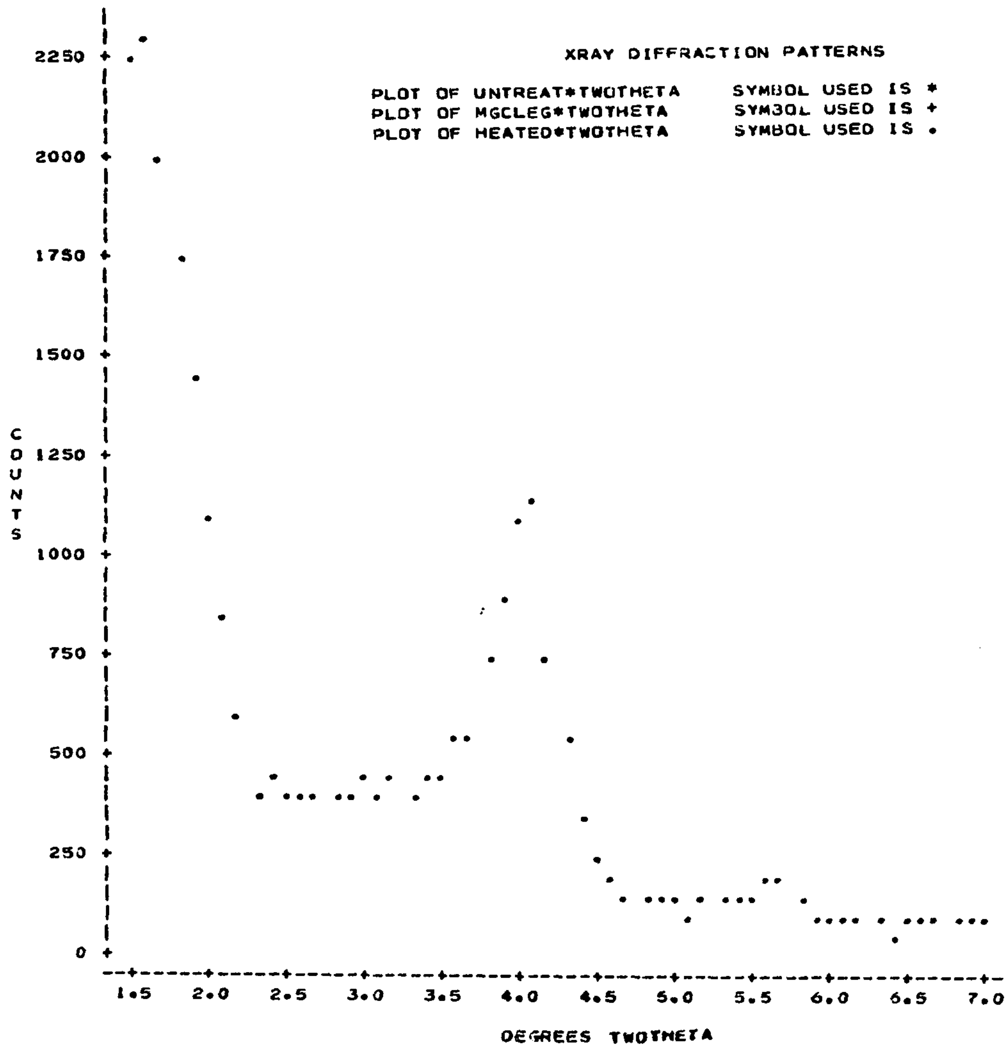

Figure 52. X-ray diffraction pattern for soil 21 (53-61 cm)

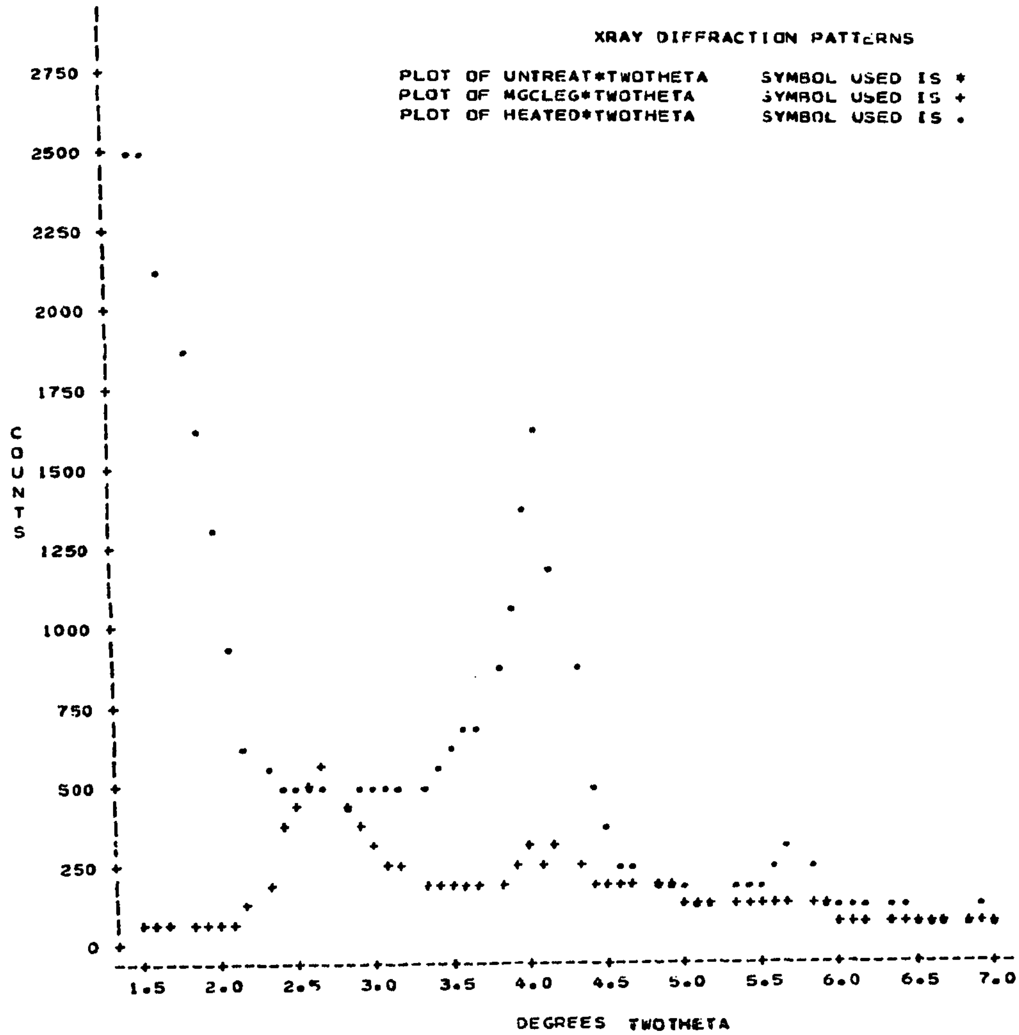

Figure 53. X-ray diffraction patterns for soil 21 (127-140 cm)

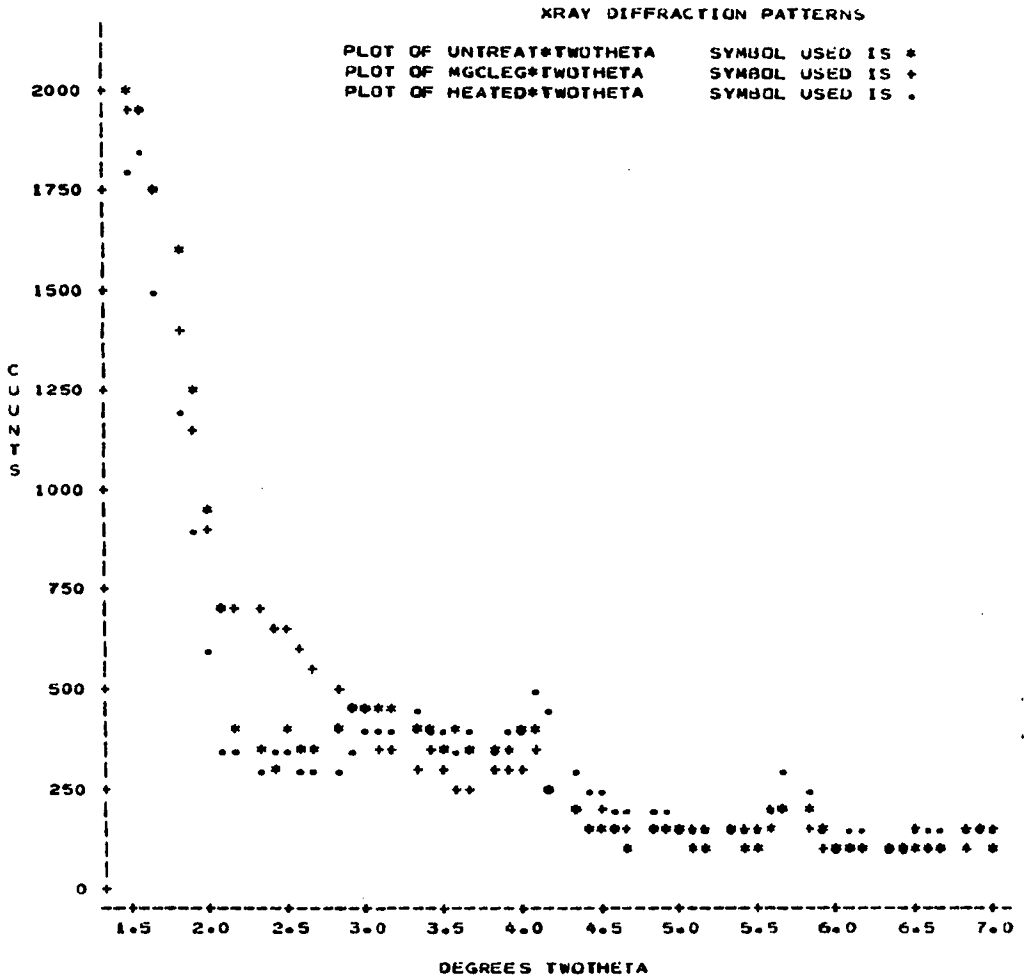

Figure 54. X-ray diffraction patterns for soil 31-2 (0-5 cm)

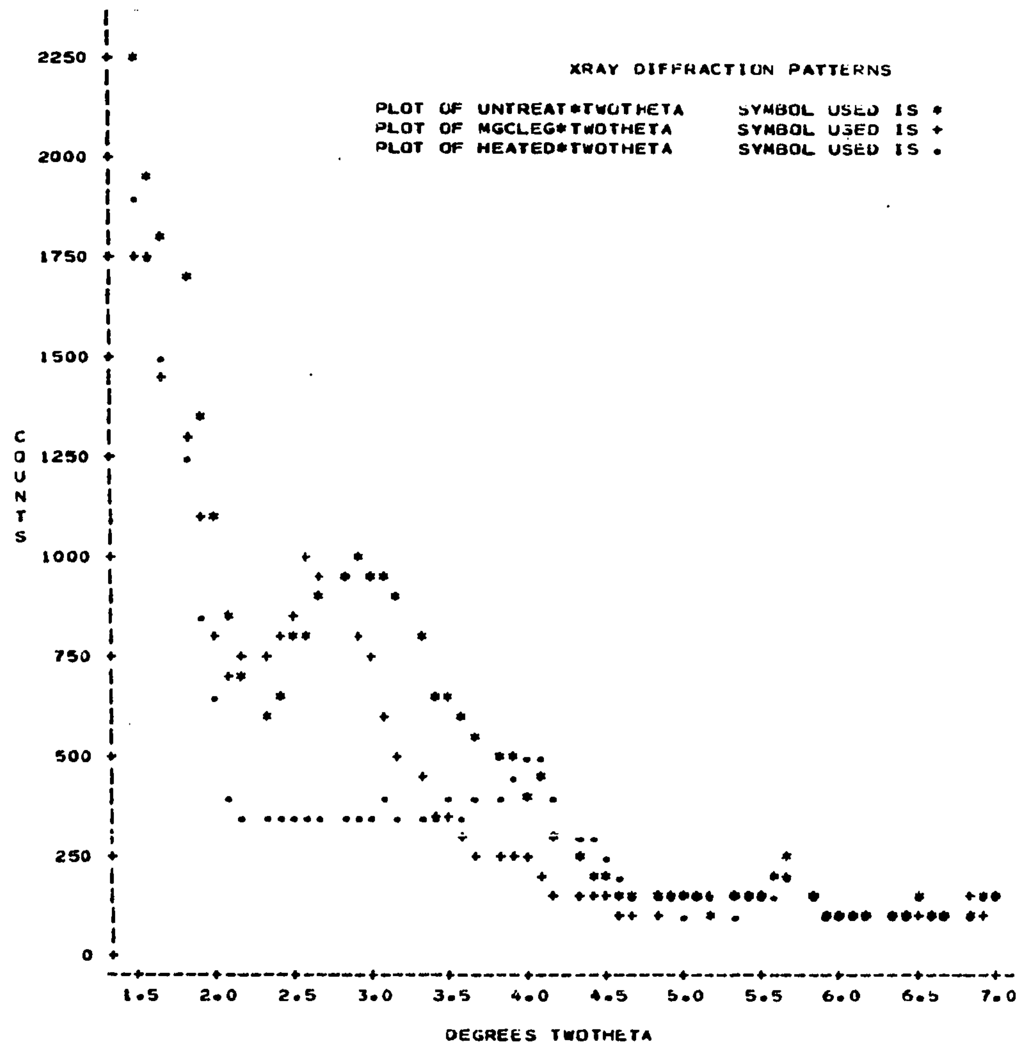

Figure 55. X-ray diffraction patterns for soil 31-2 (51-56 cm)

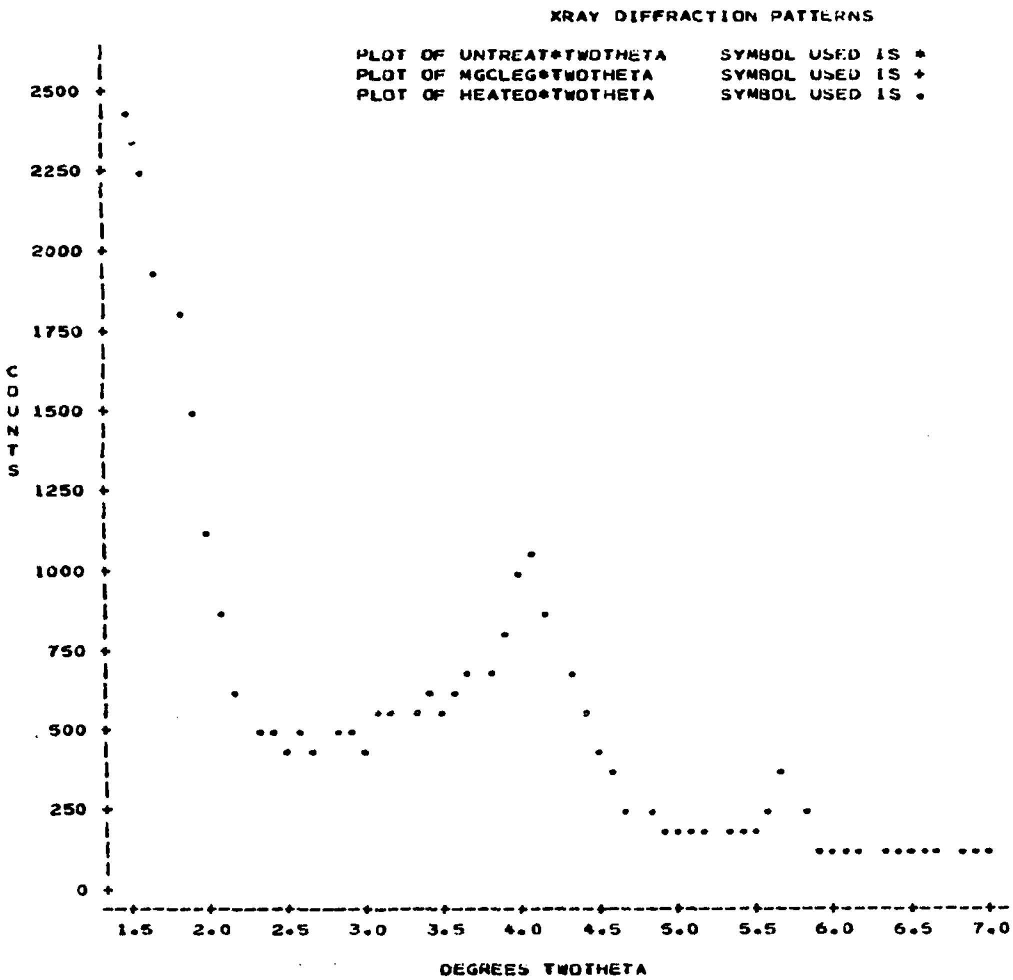

Figure 56. X-ray diffraction patterns for soil 31-2 (91-97 cm)

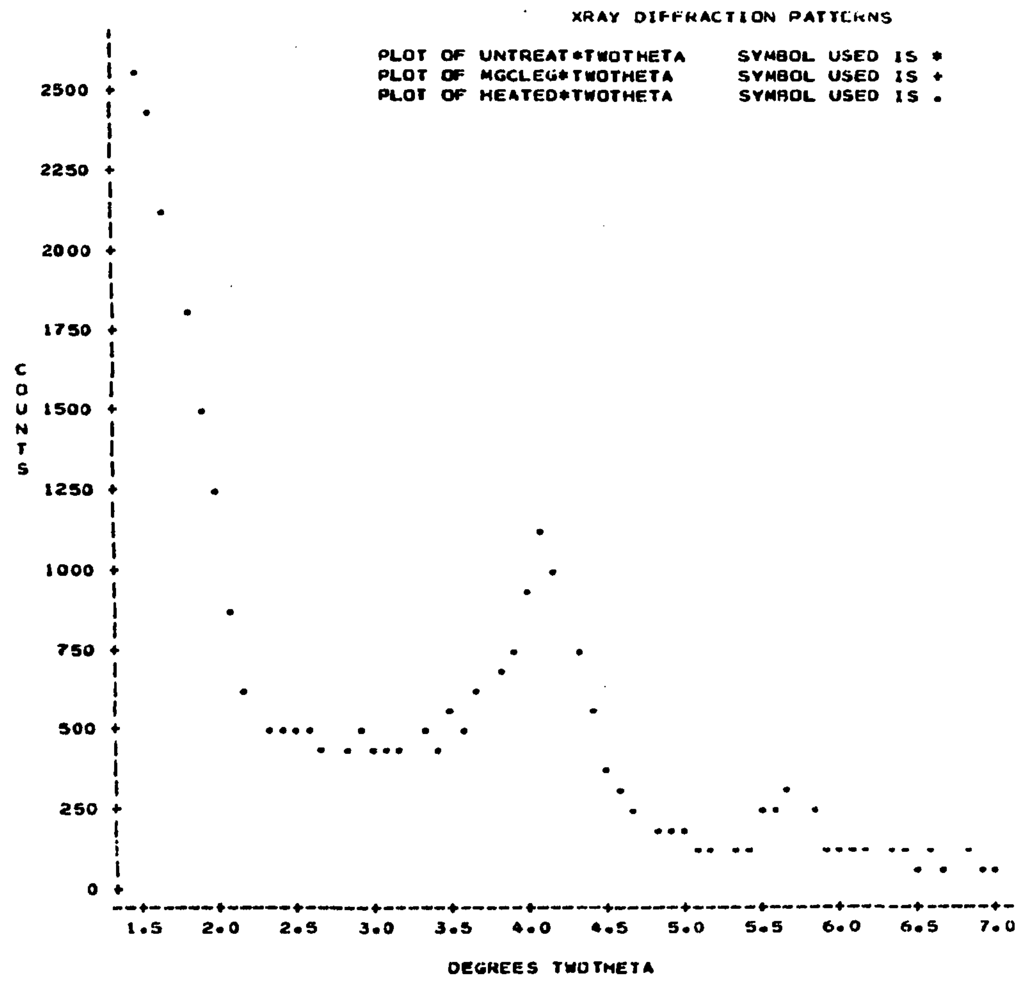

Figure 57. X-ray diffraction patterns for soil 31-2 (107-112 cm)

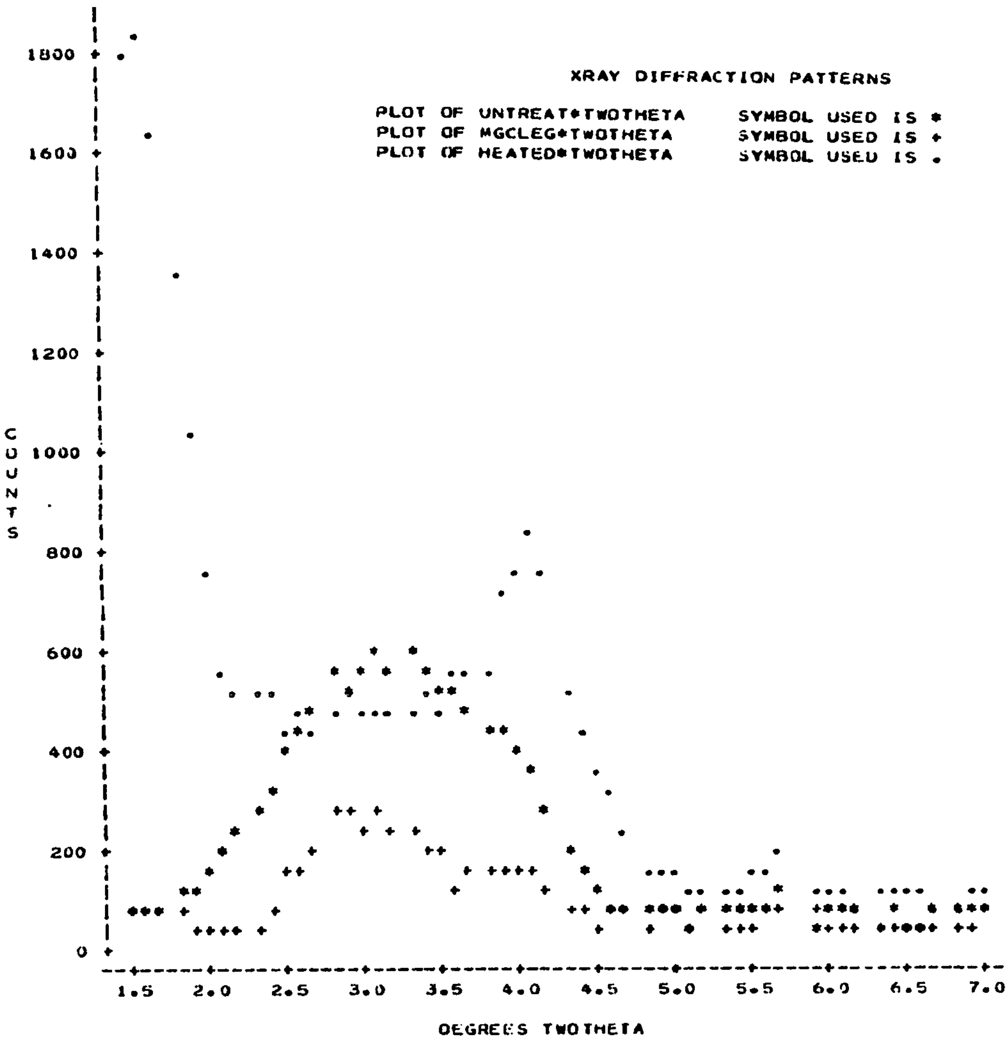

Figure 58. X-ray diffraction patterns for soil 36 (0-18 cm)

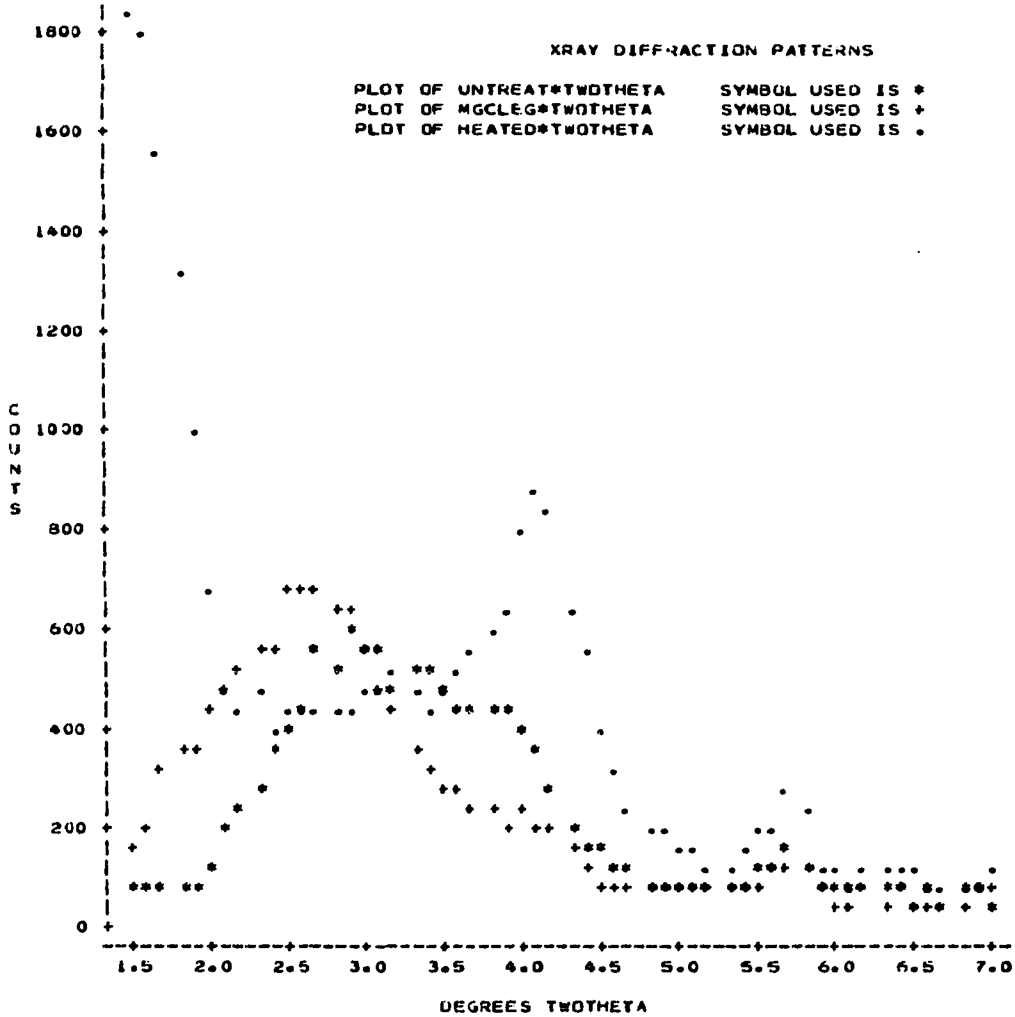

Figure 59. X-ray diffraction patterns for soil 36 (41-51 cm)

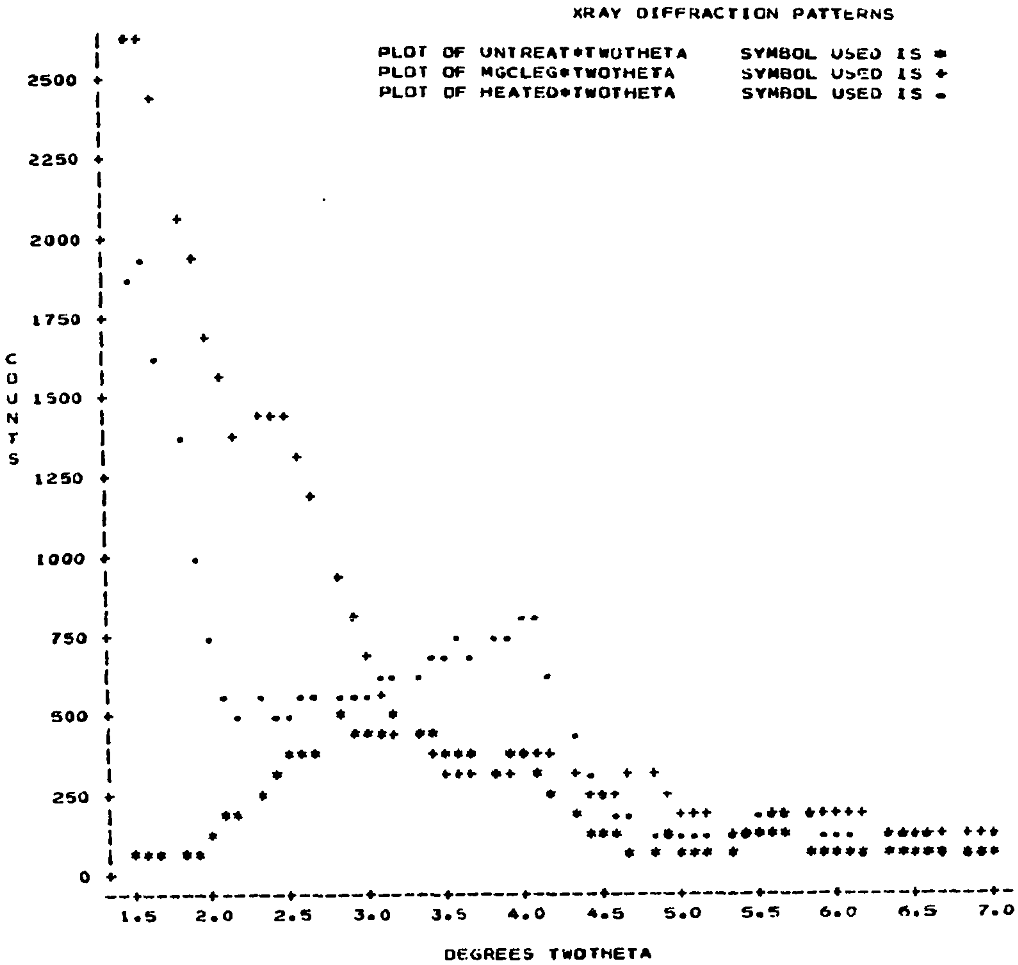

Figure 60. X-ray diffraction patterns for soil 36 (140-152 cm)

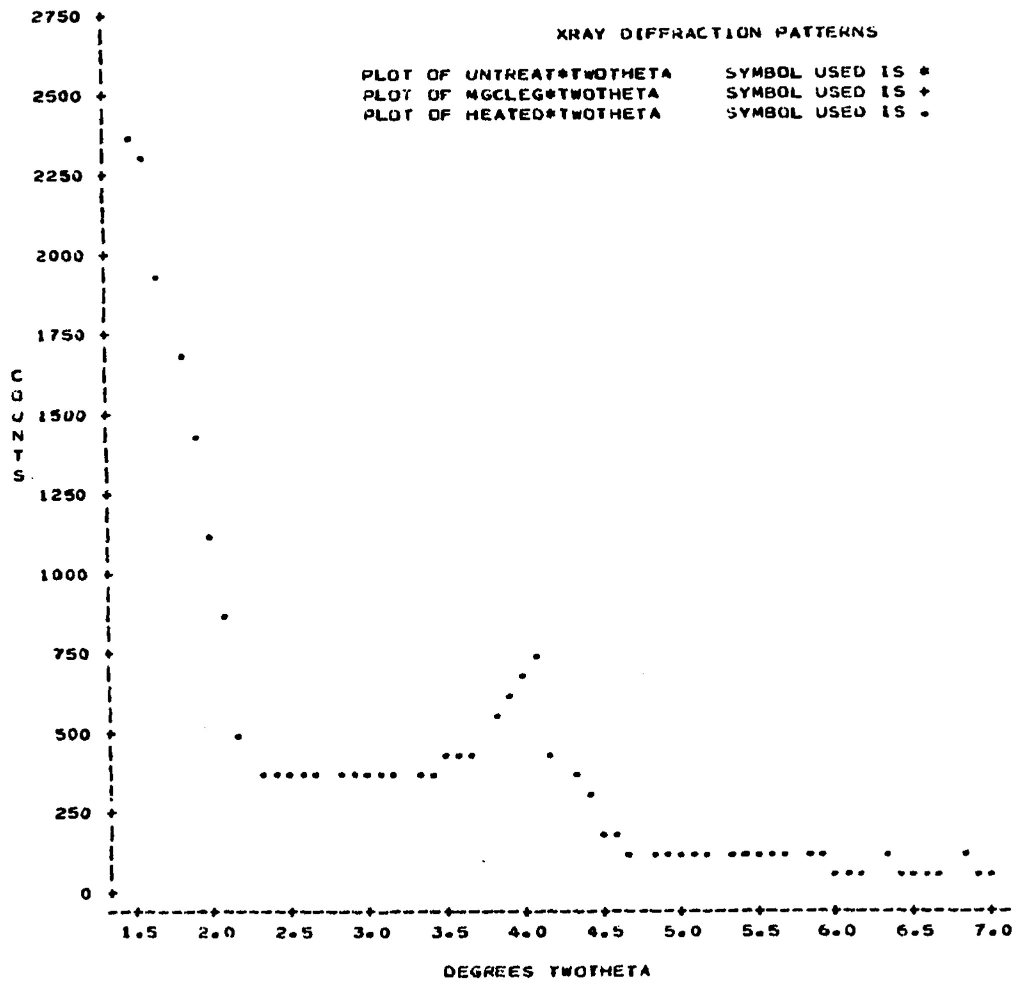

Figure 61. X-ray diffraction patterns for soil 63 (0-10 cm)

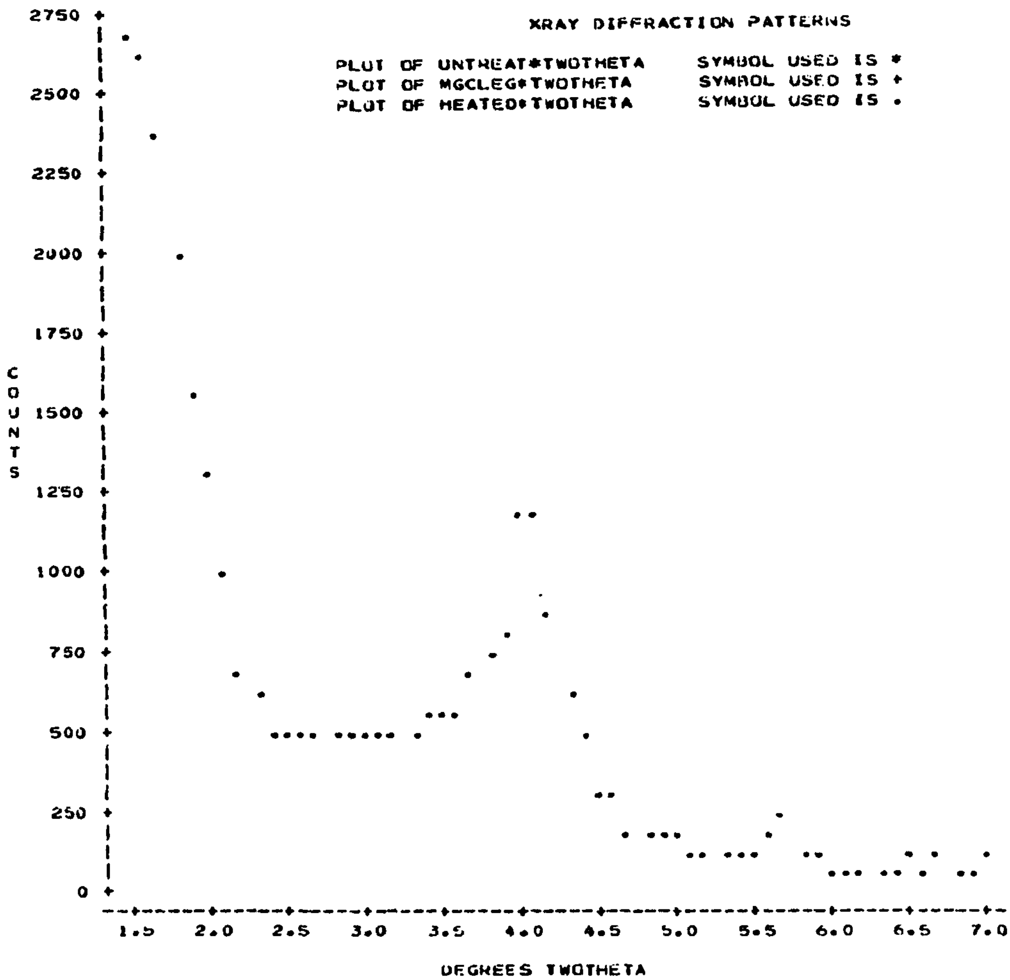

Figure 62. X-ray diffraction patterns for soil 63 (81-94 cm)

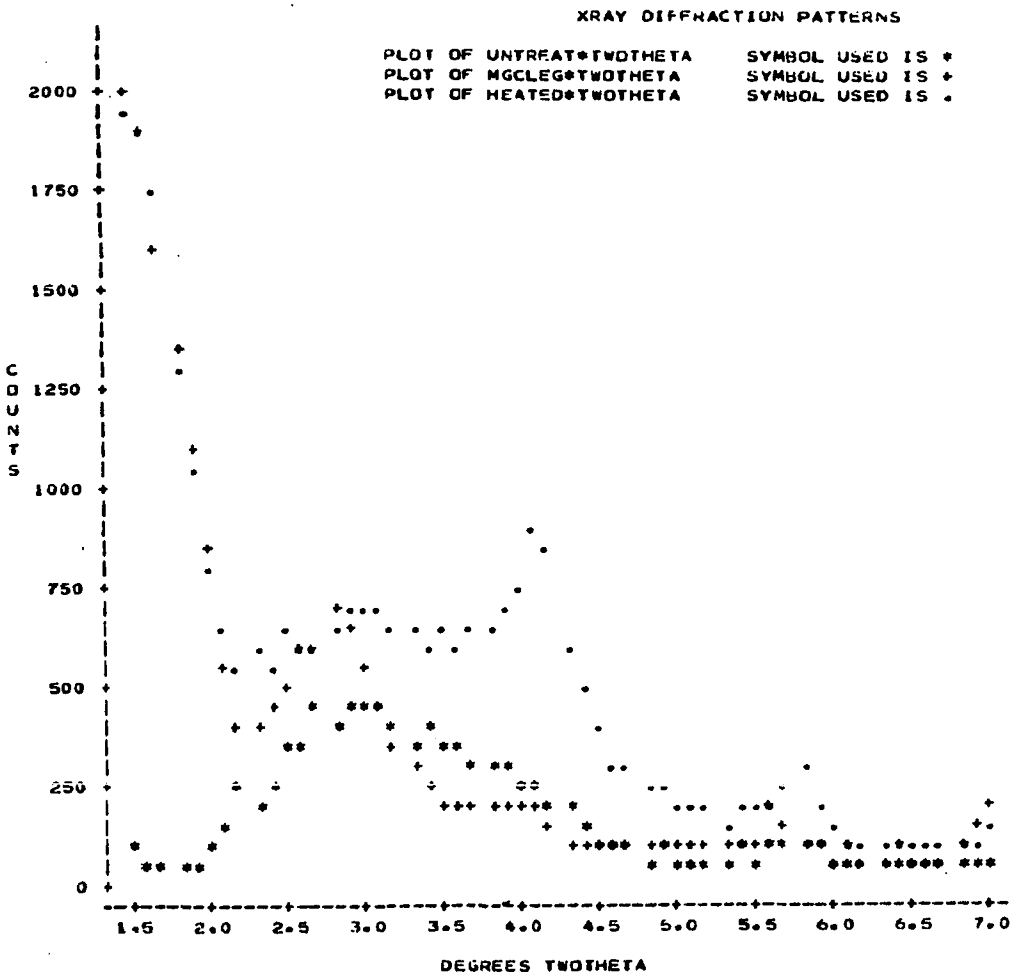

Figure 63. X-ray diffraction patterns for soil 56 (0-13 cm)

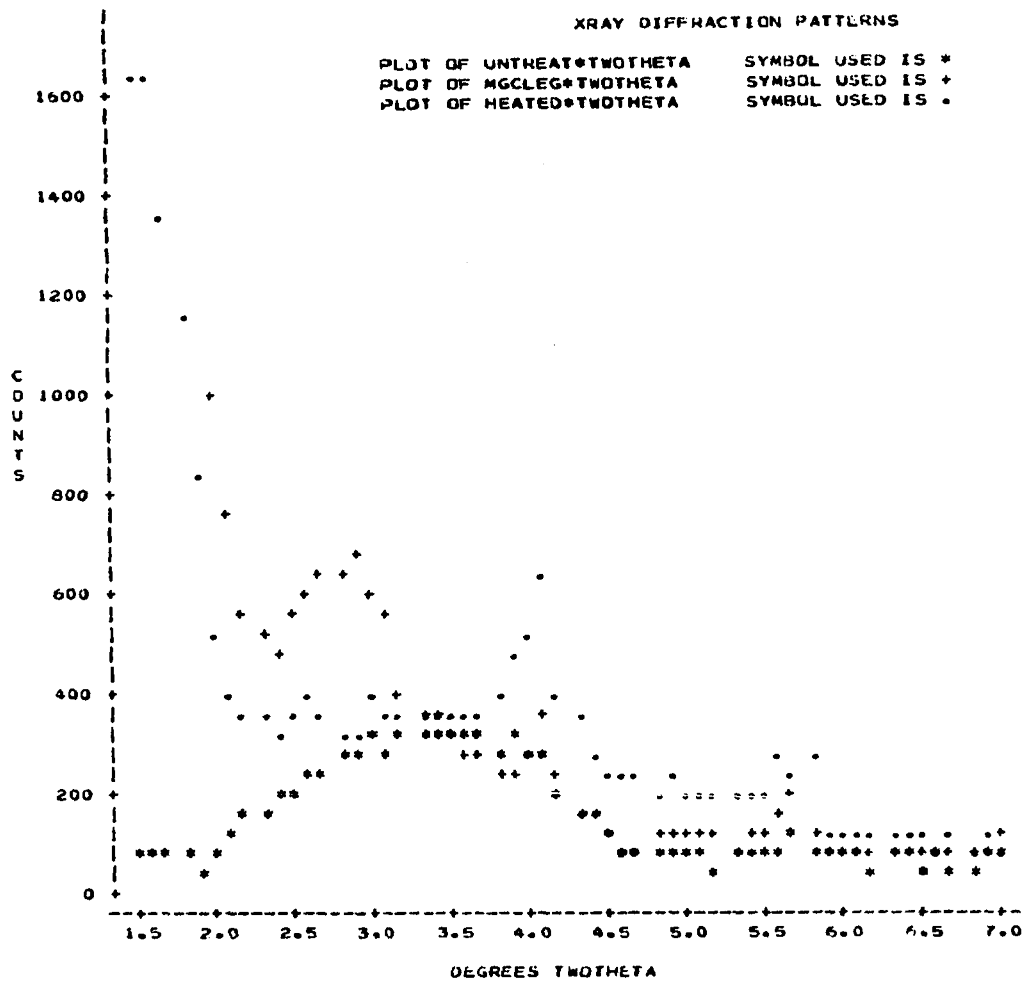

Figure 64. X-ray diffraction patterns for soil 56 (61-76 cm)

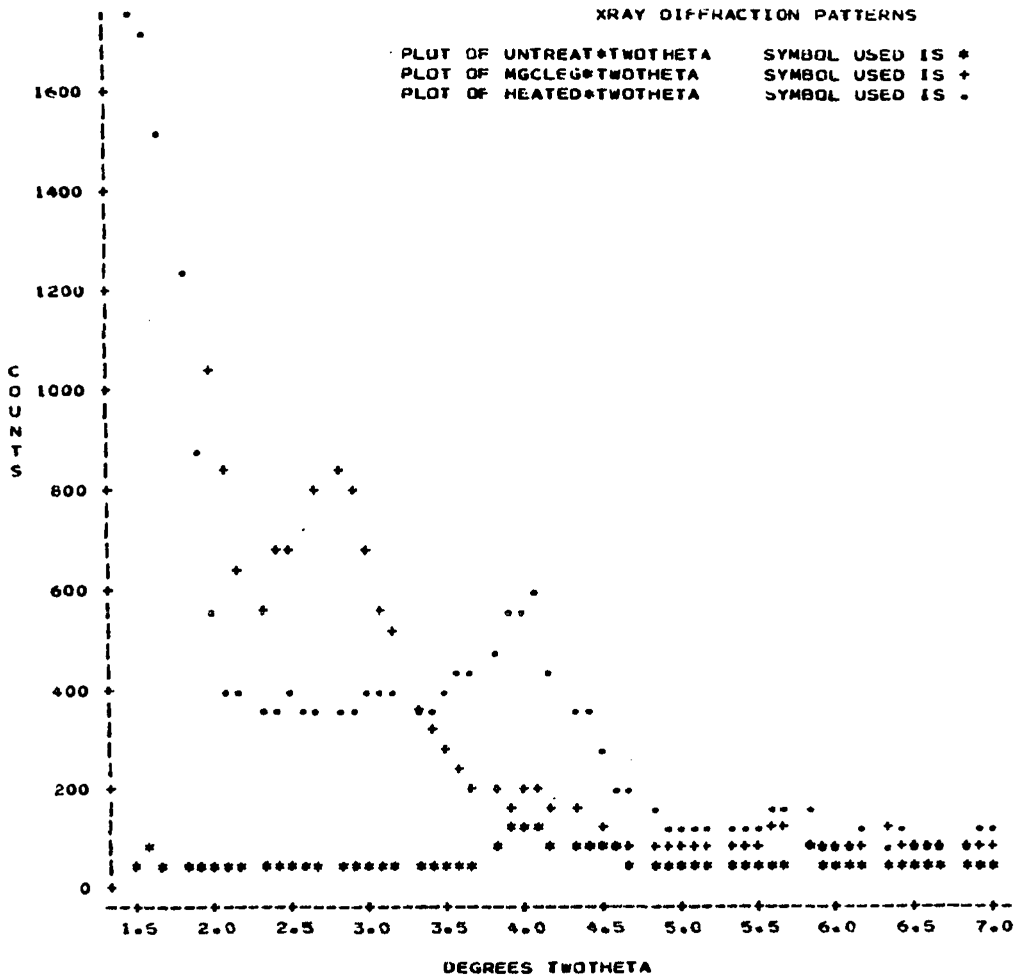

Figure 65. X-ray diffraction patterns for soil 56 (135-152 cm)

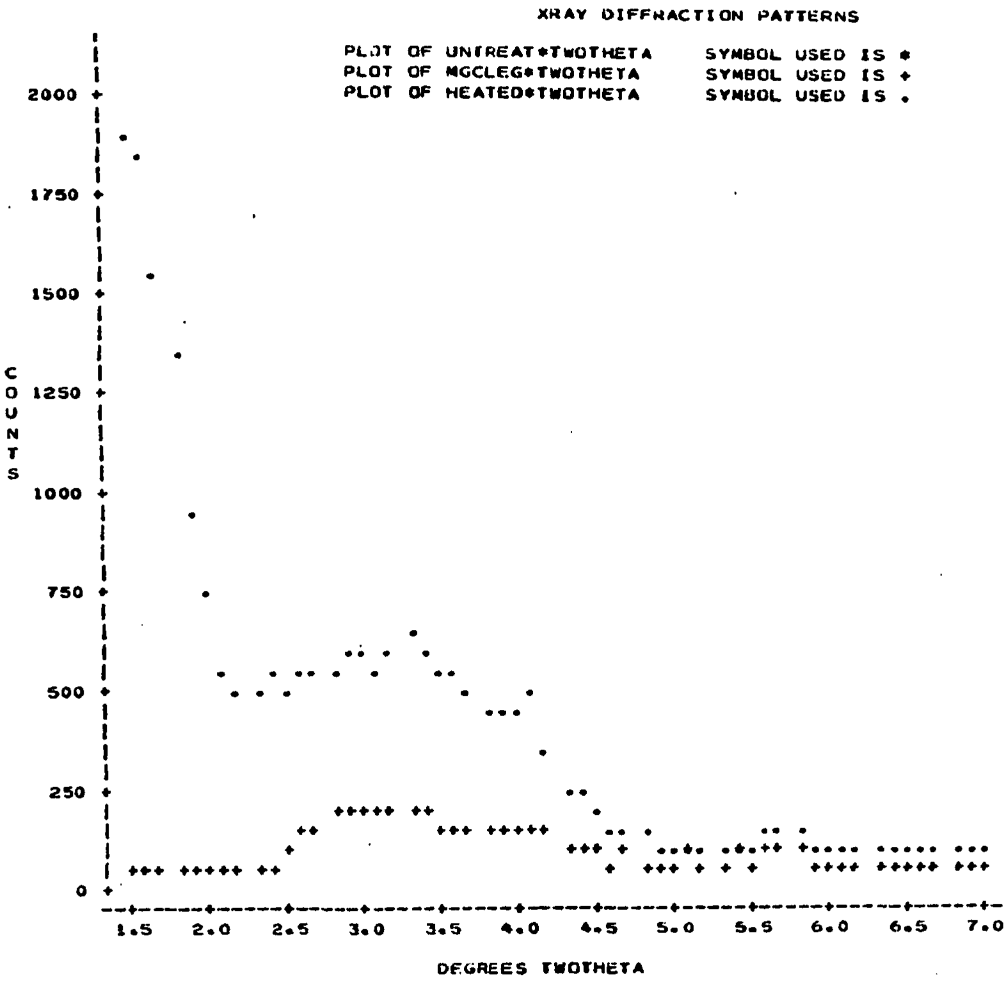

Figure 66. X-ray diffraction patterns for soil 60 (0-18 cm)

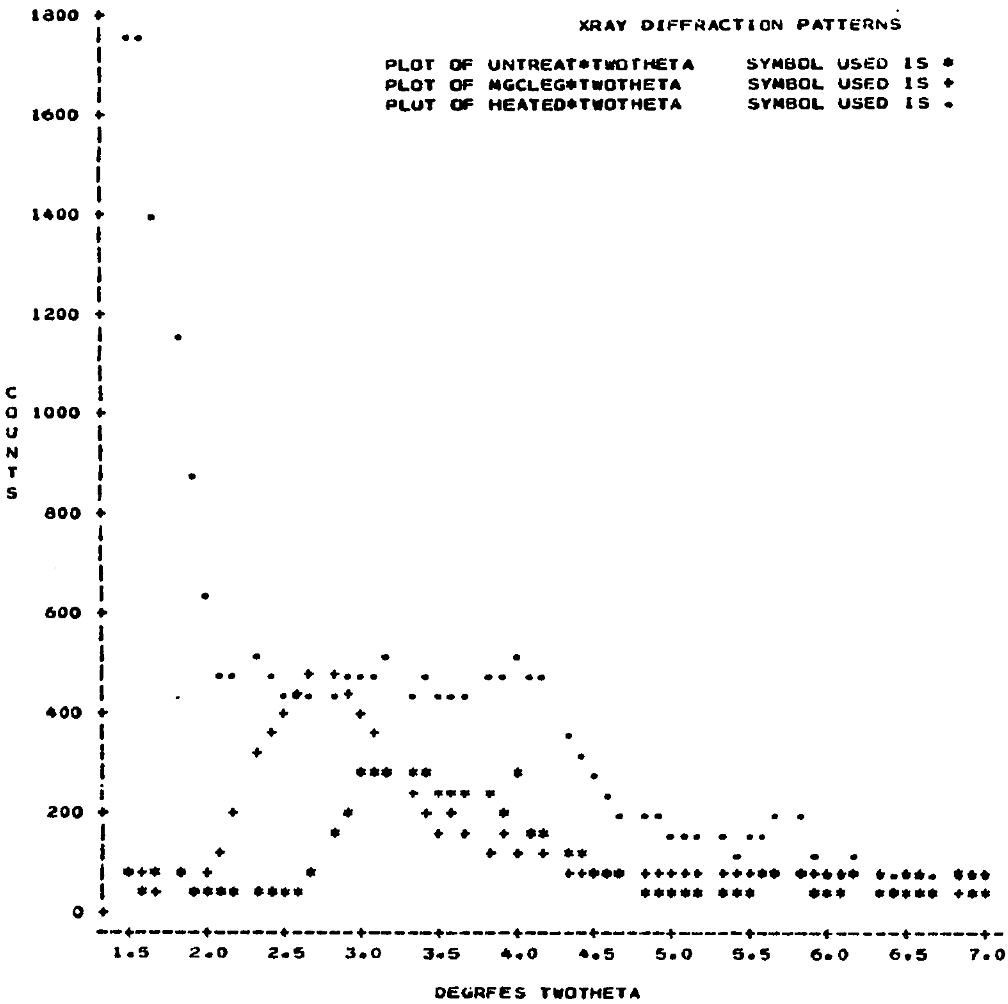

Figure 67. X-ray diffraction patterns for soil 60 (53-71 cm)

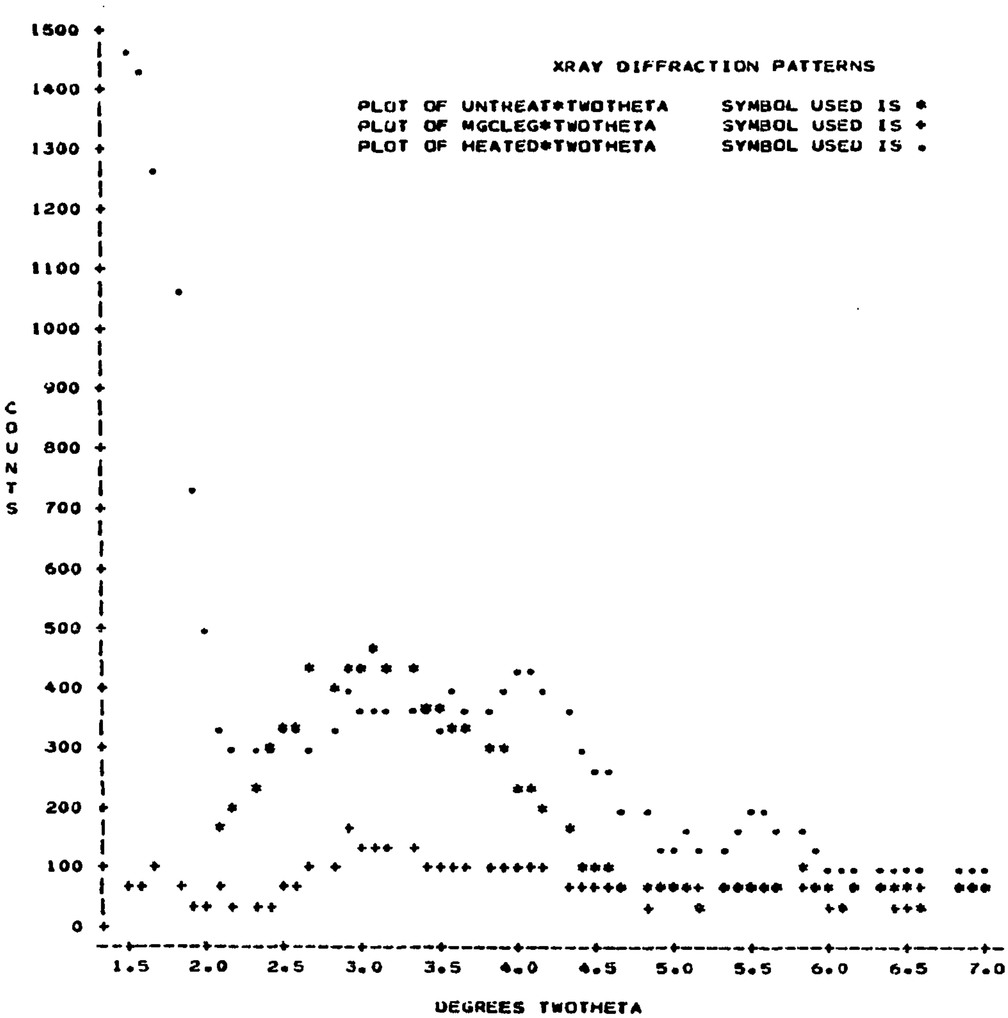

Figure 68. X-ray diffraction patterns for soil 60 (123-145 cm)

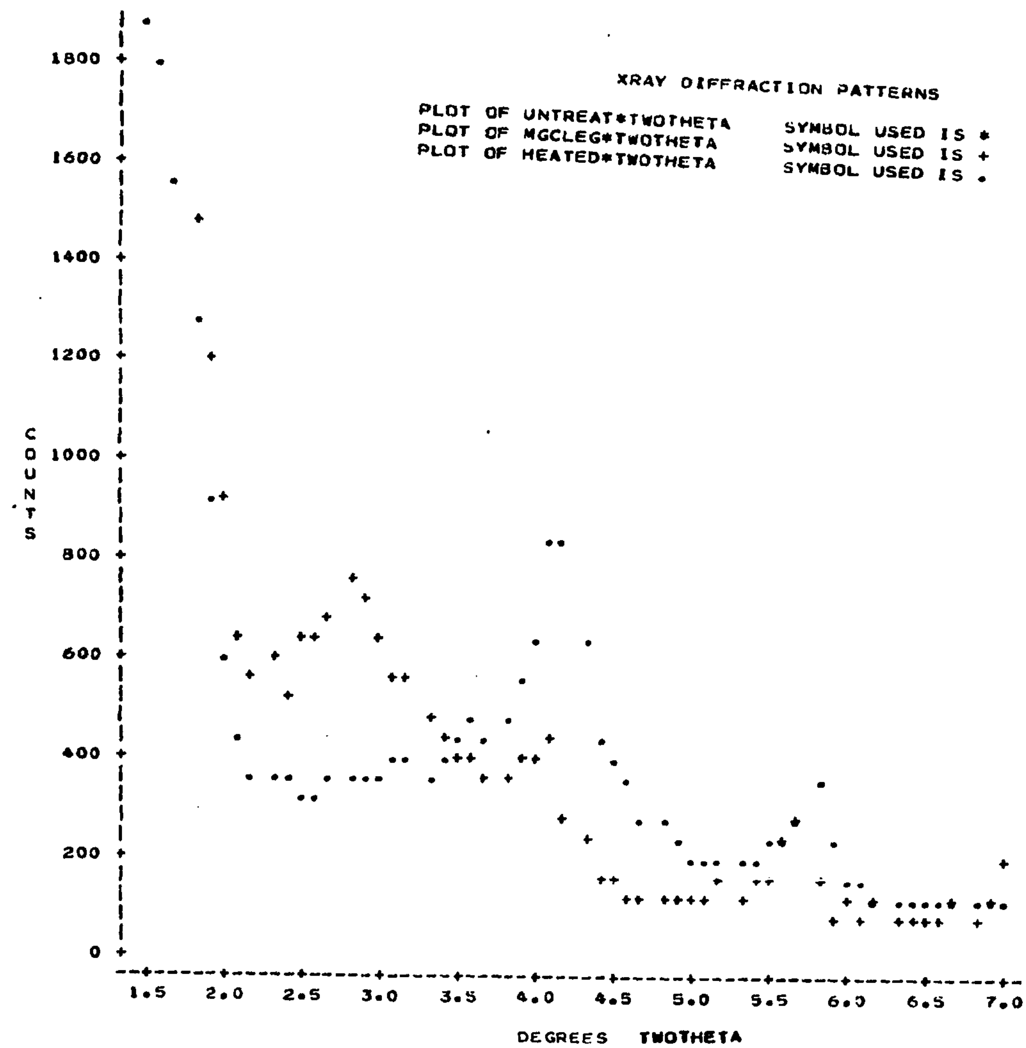

Figure 69. X-ray diffraction patterns for soil 71 (0-13 cm)

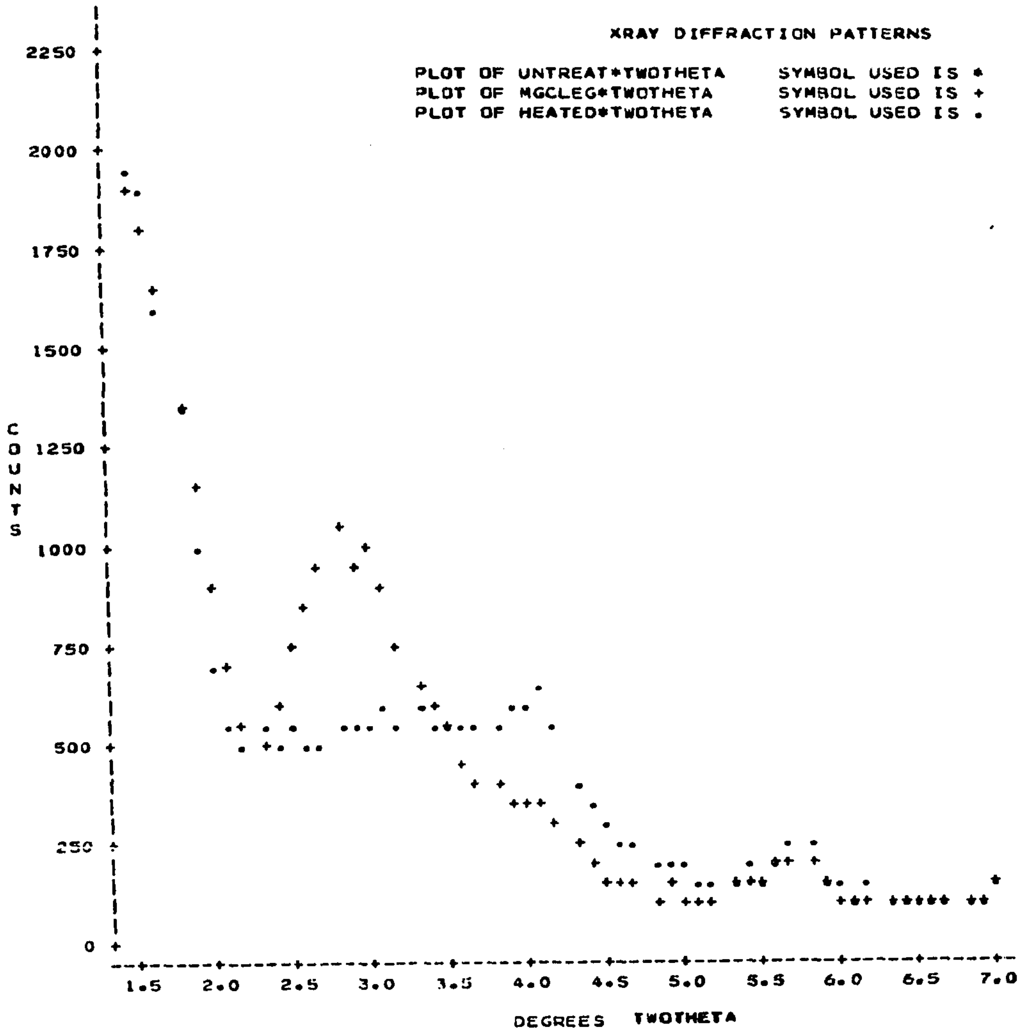

Figure 70. X-ray diffraction patterns for soil 71 (51-66 cm)

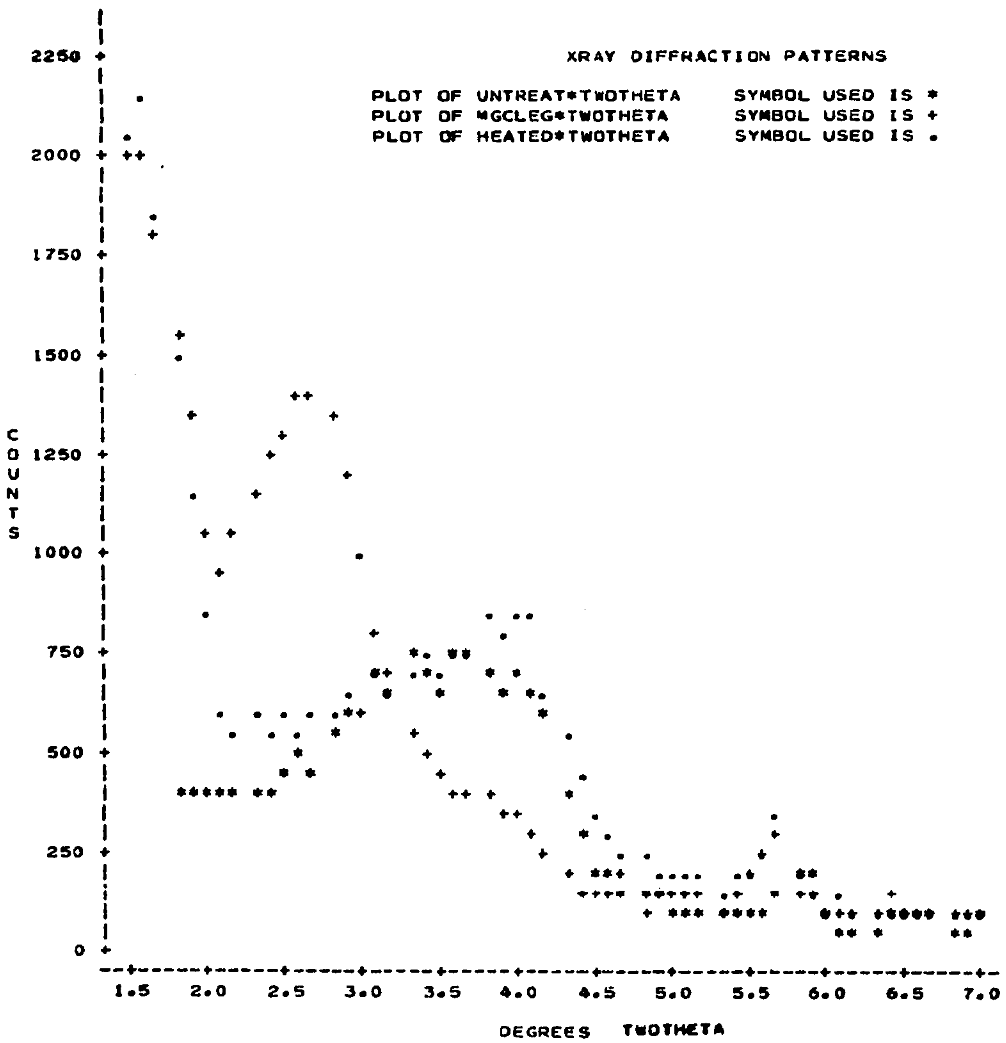

Figure 71. X-ray diffraction patterns for soil 71
(130-152 cm)

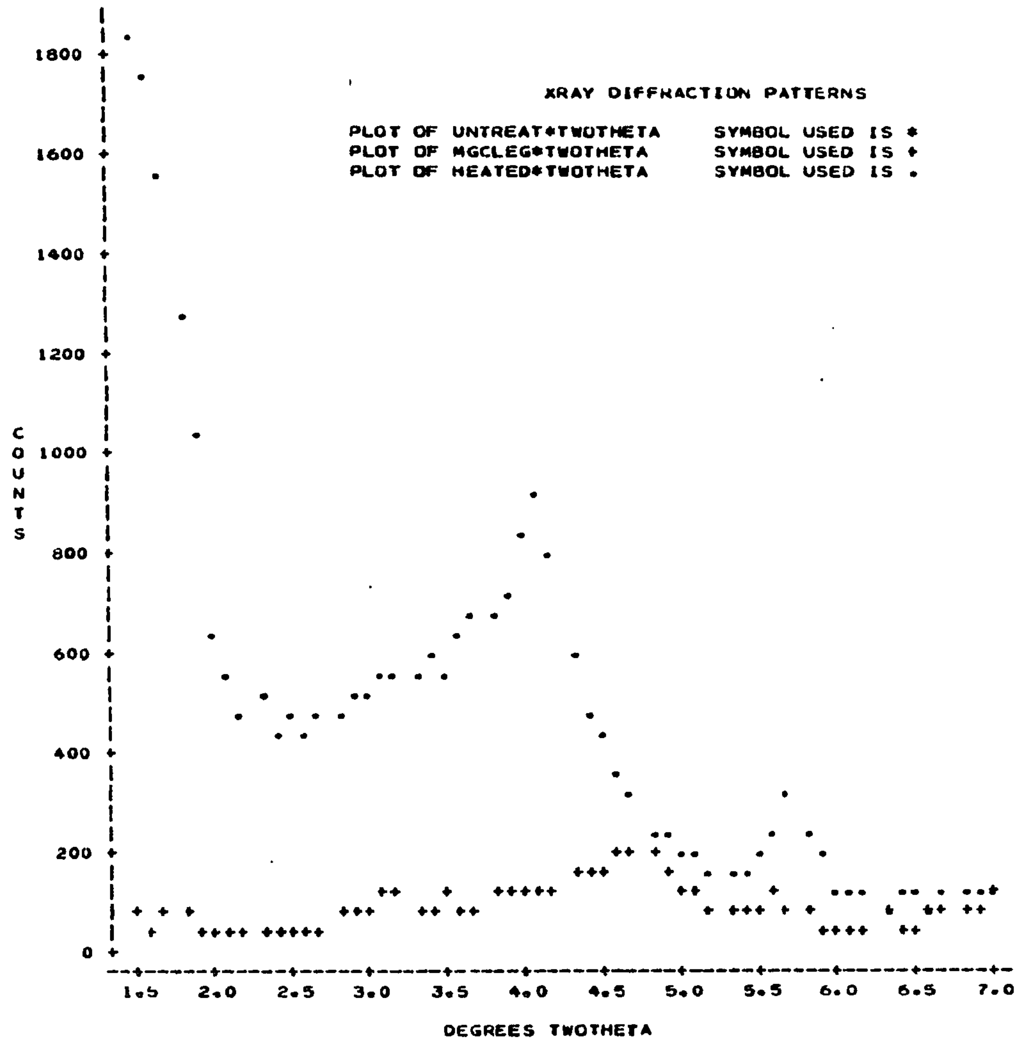

Figure 72. X-ray diffraction patterns for soil 95 (0-5 cm)

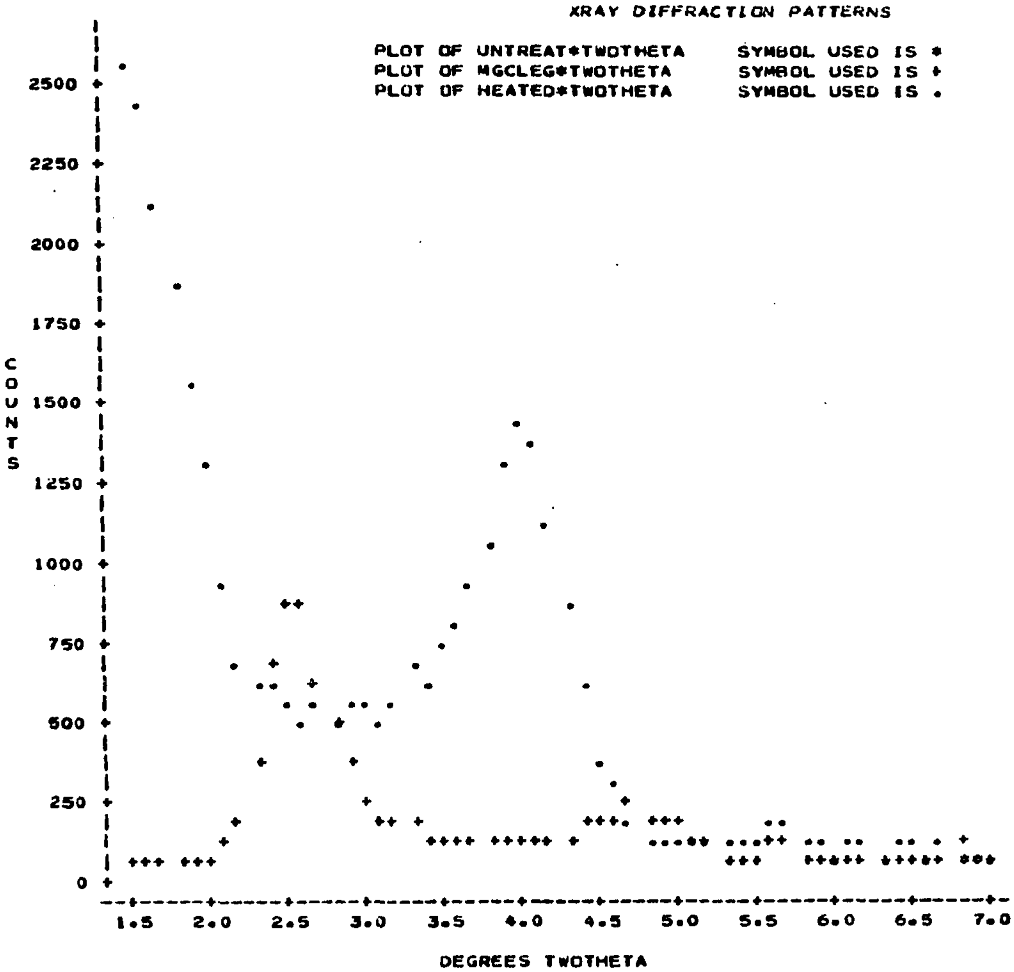

Figure 73. X-ray diffraction patterns for soil 95 (30-36 cm)

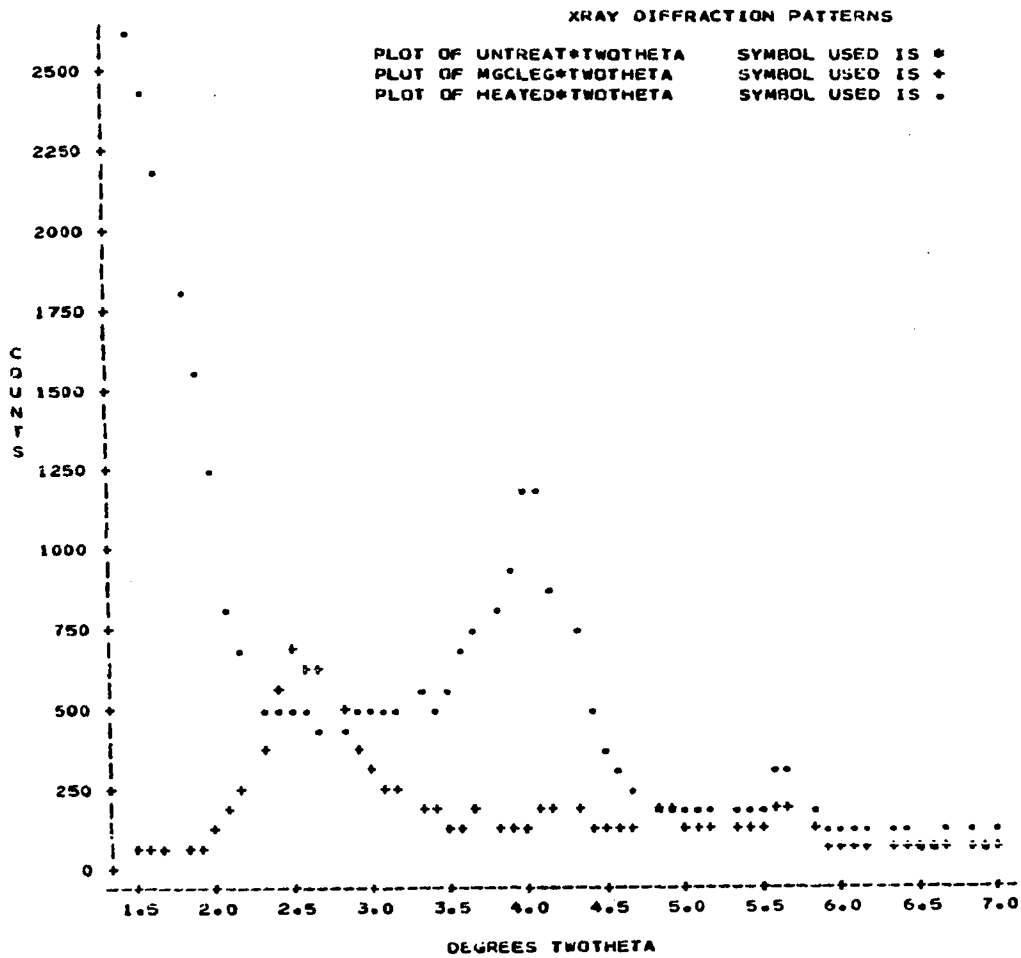

Figure 74. X-ray diffraction patterns for soil 95 (66-71 cm)

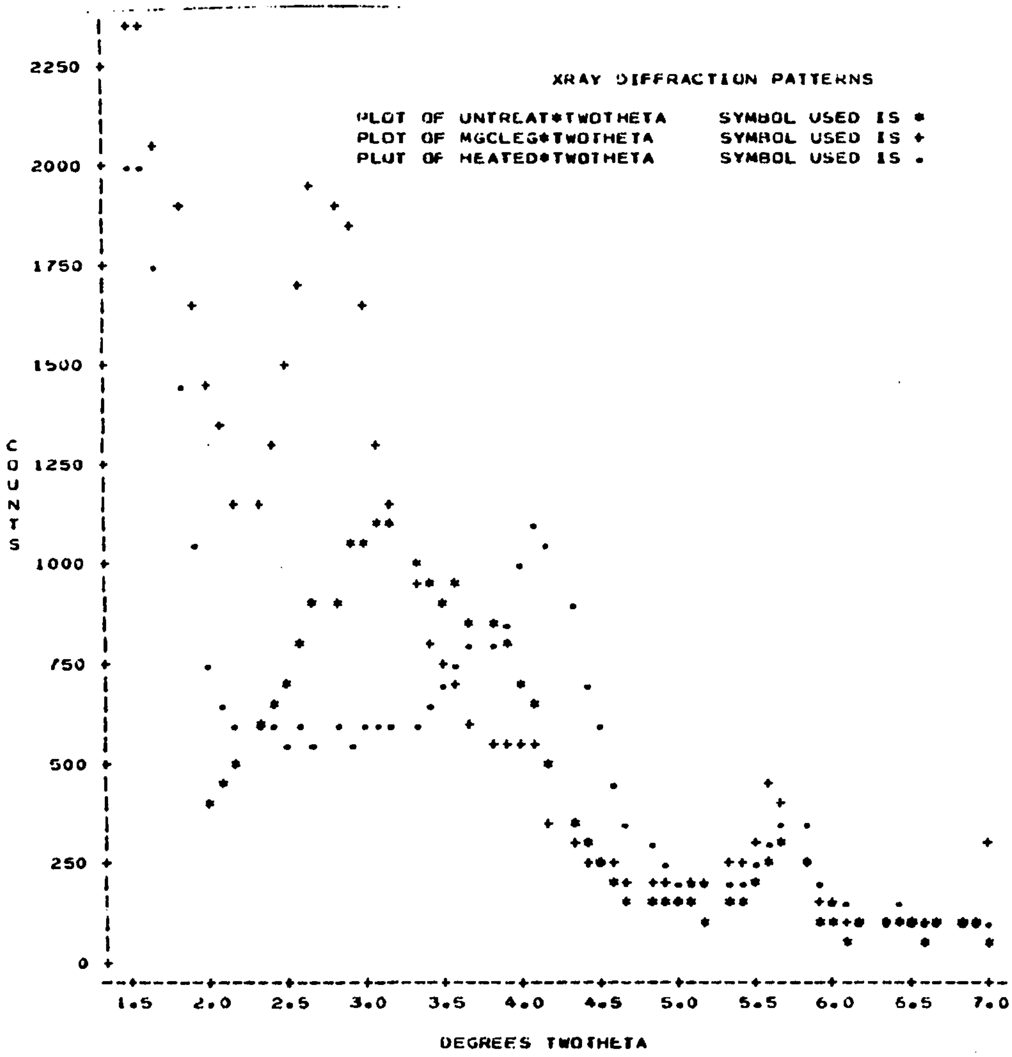

Figure 75. X-ray diffraction patterns for soil 95 (101-106 cm)

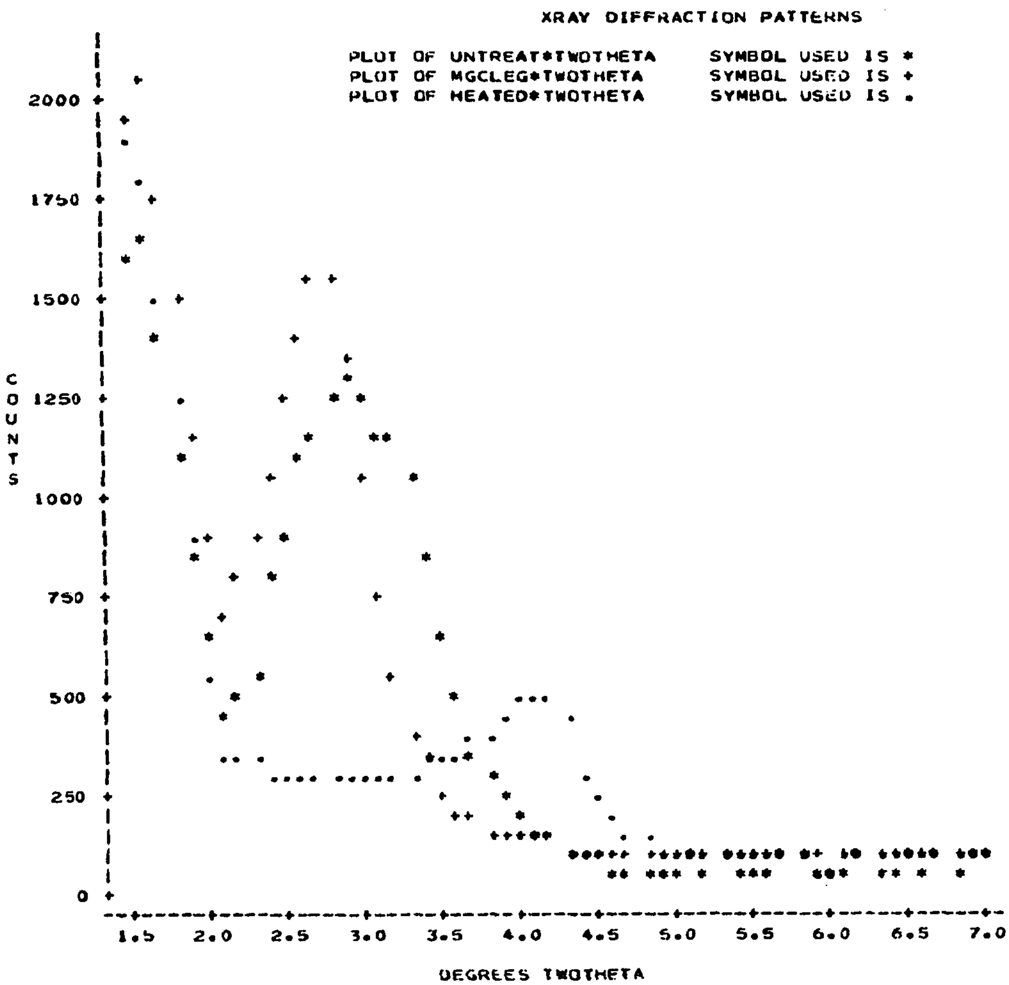

Figure 76. X-ray diffraction patterns for soil 95 (135-152 cm)

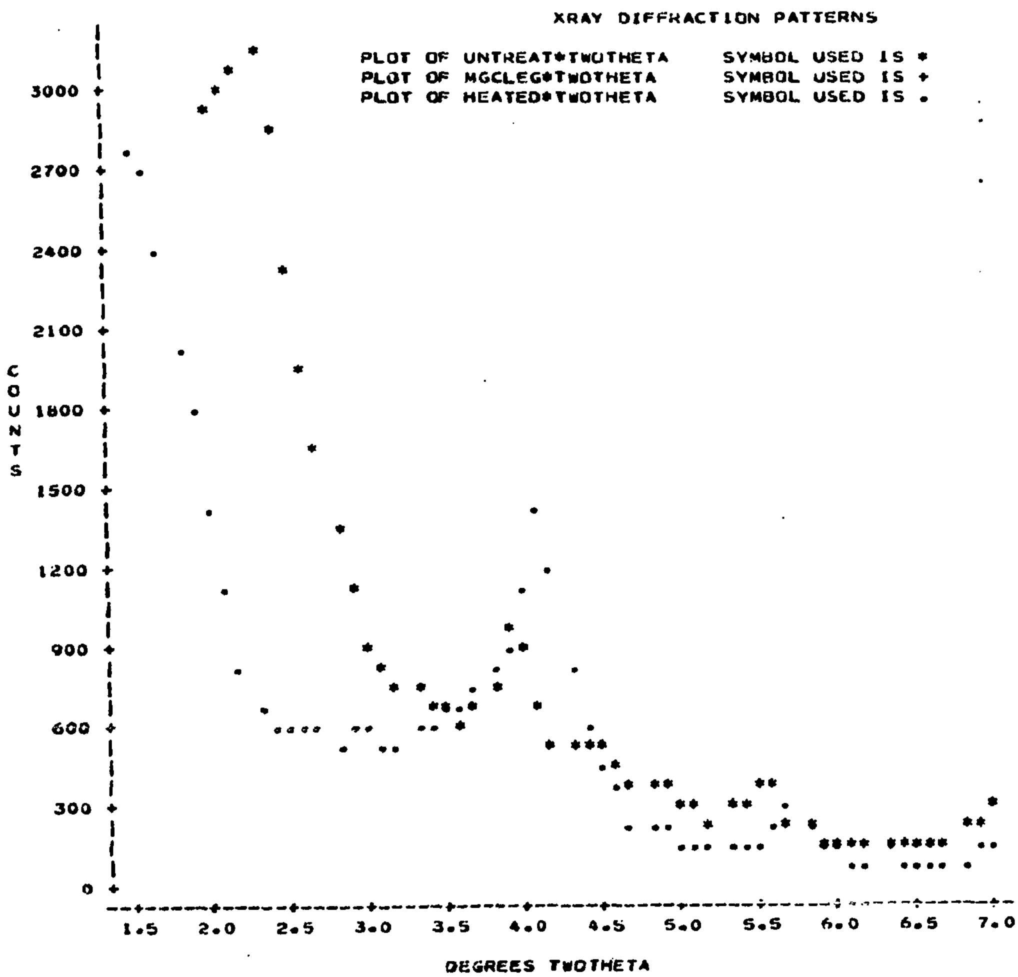

Figure 77. X-ray diffraction patterns for soil N2 (0-18 cm)

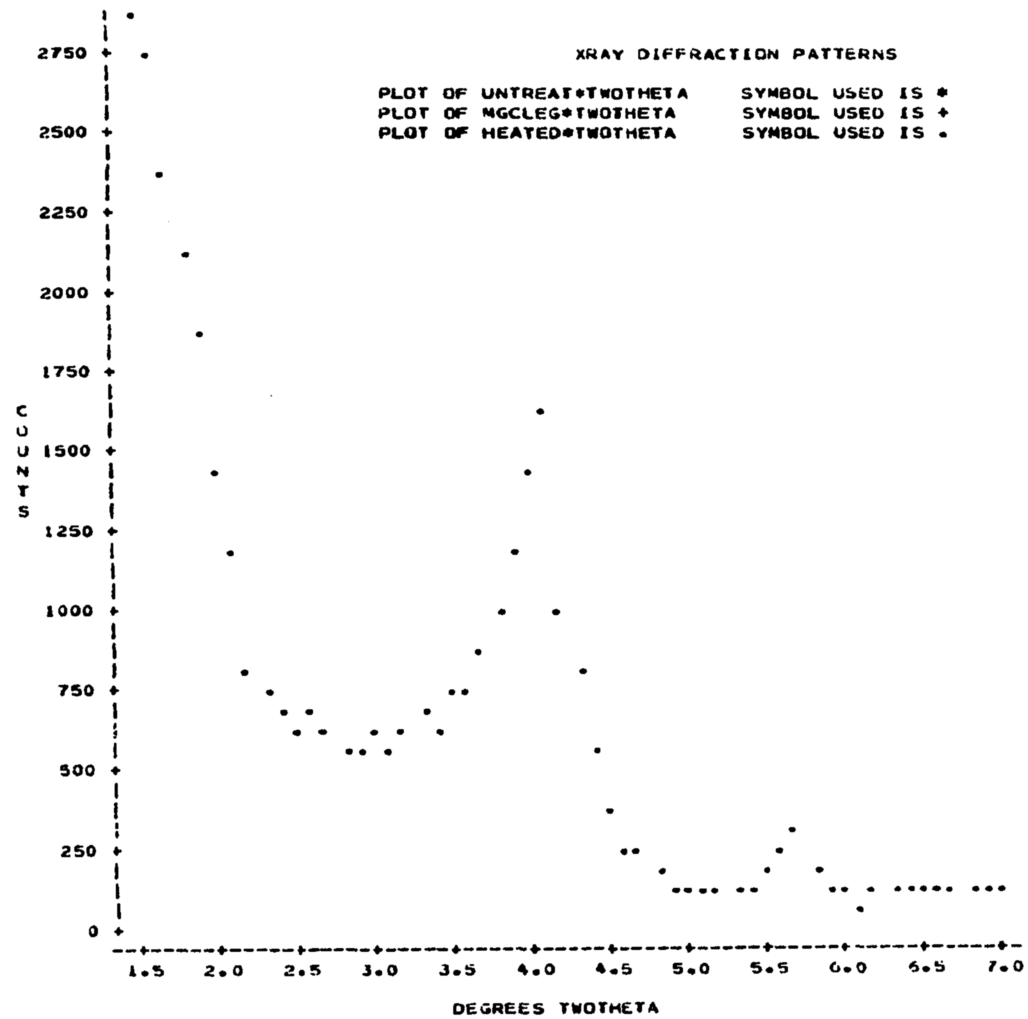

Figure 78. X-ray diffraction pattern for soil N2 (48-66 cm)

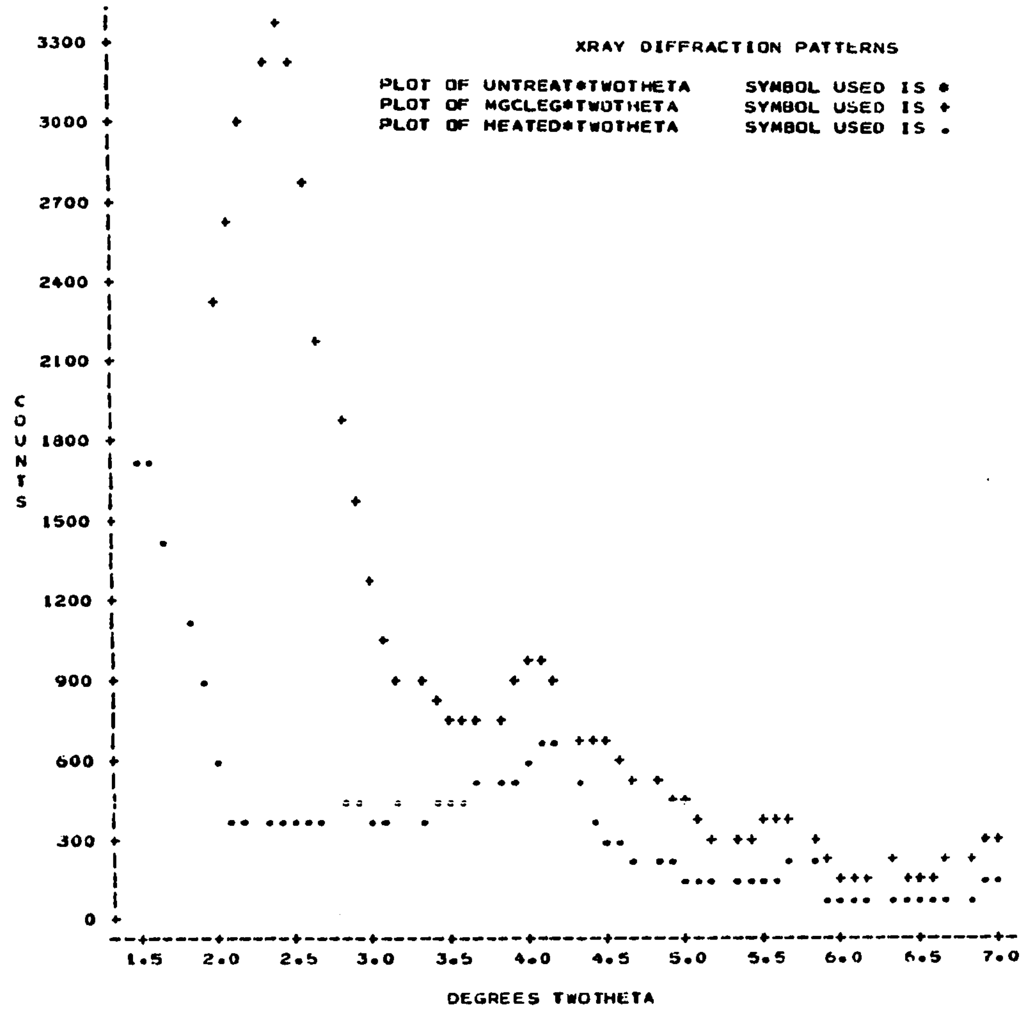

Figure 79. X-ray diffraction patterns for soil N2 (132-152 cm)

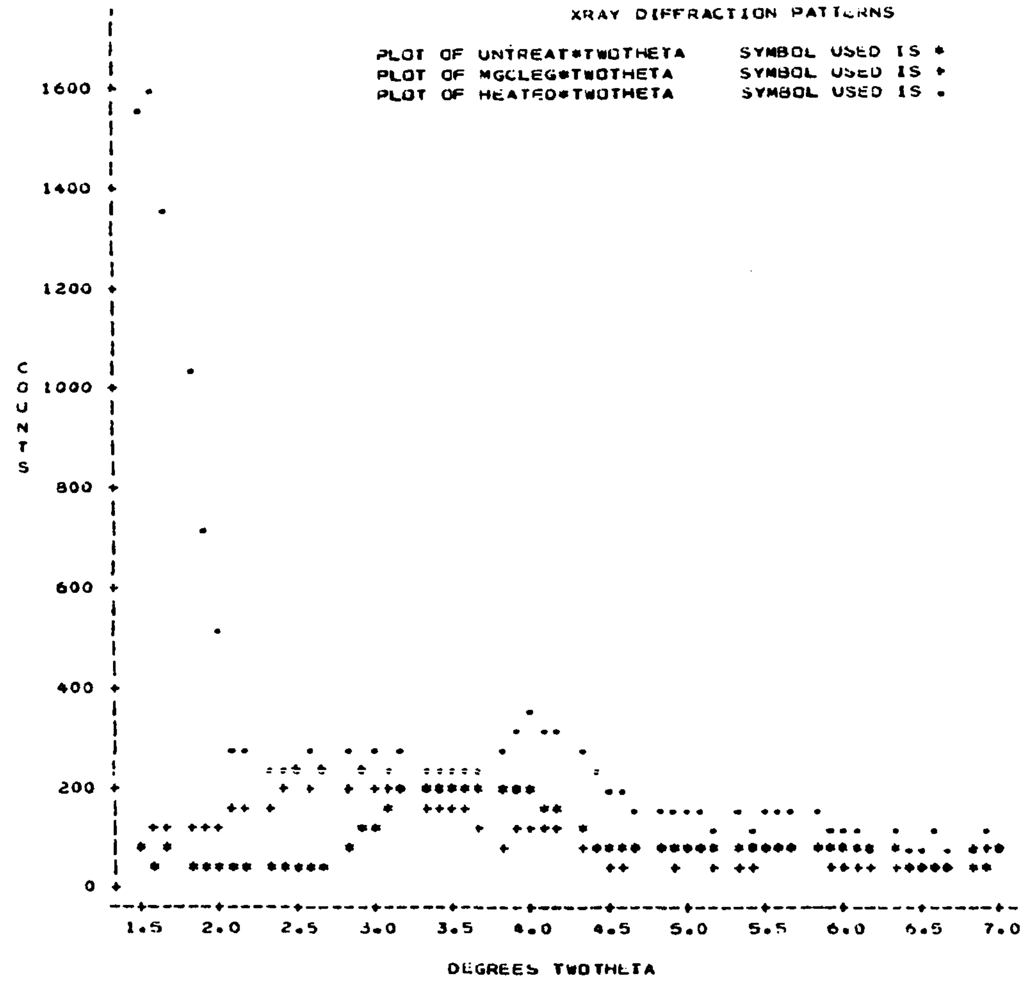

Figure 80. X-ray diffraction patterns for soil M3 (0-18 cm)

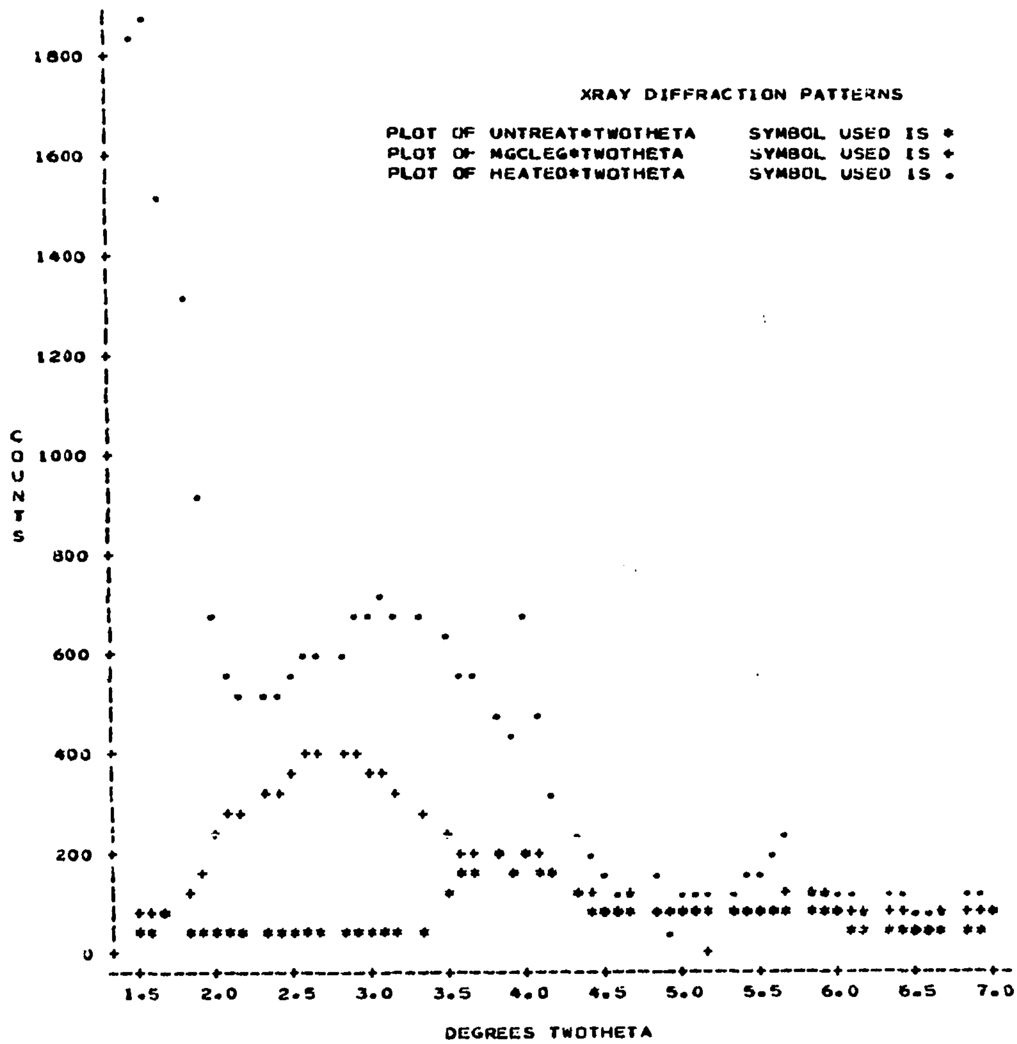

Figure 81. X-ray diffraction patterns for soil M3 (61-74 cm)

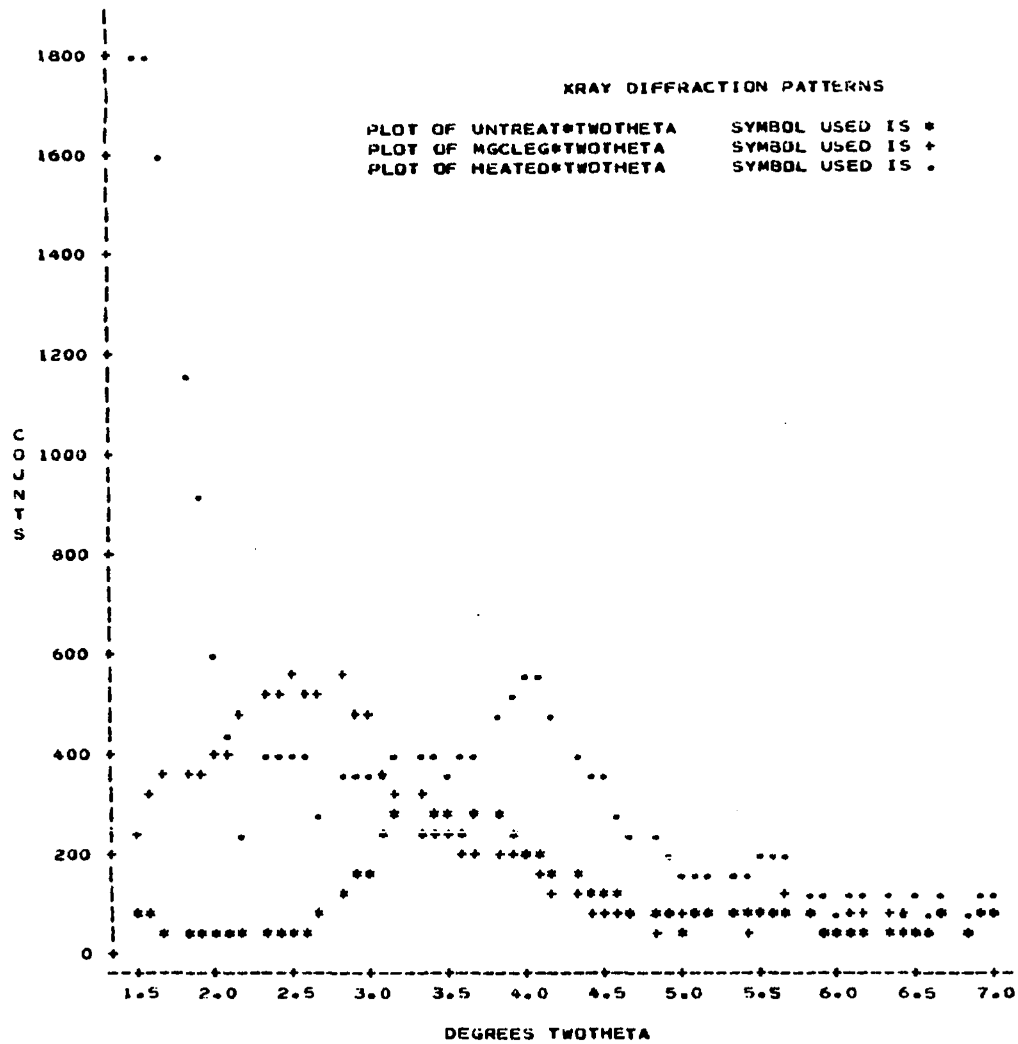

Figure 82. X-ray diffraction patterns for soil M3 (137-152 cm)

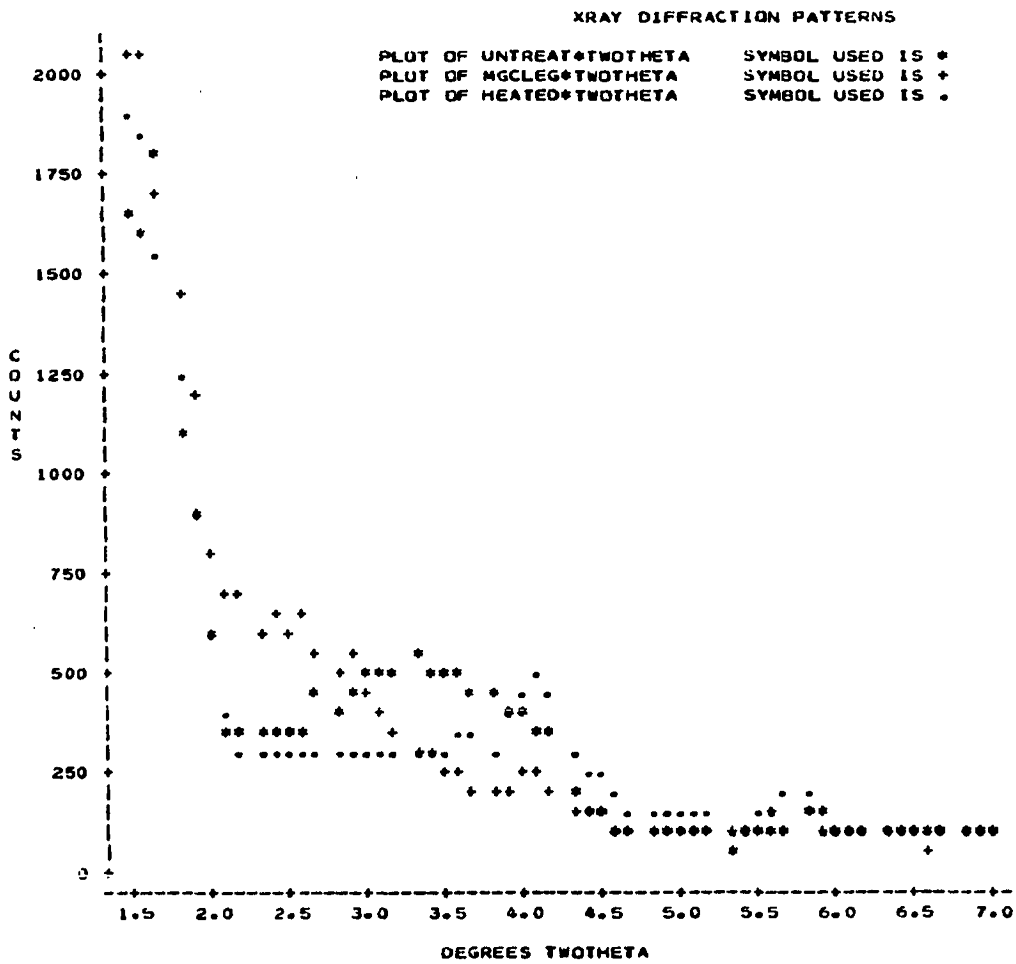

Figure 83. X-ray diffraction patterns for soil I2 (0-13 cm)

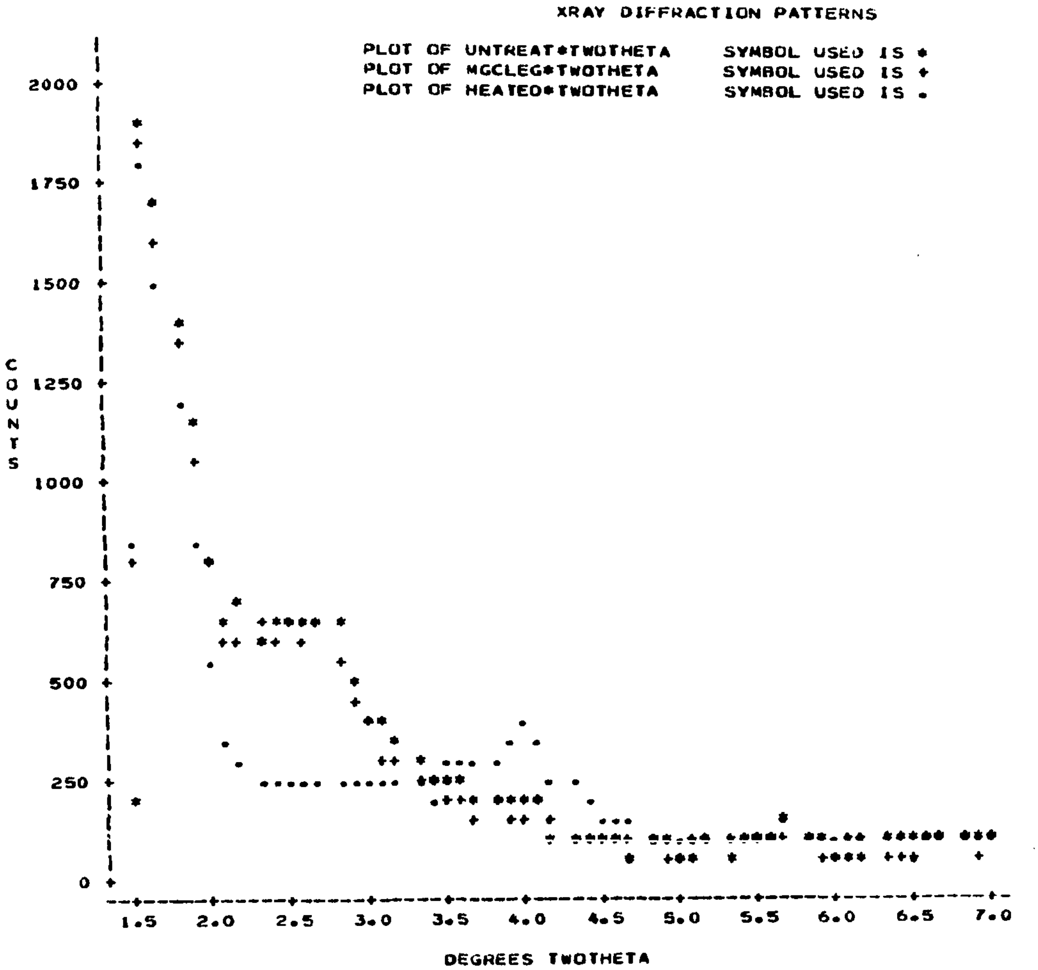

Figure 84. X-ray diffraction patterns for soil I2 (51-58 cm)

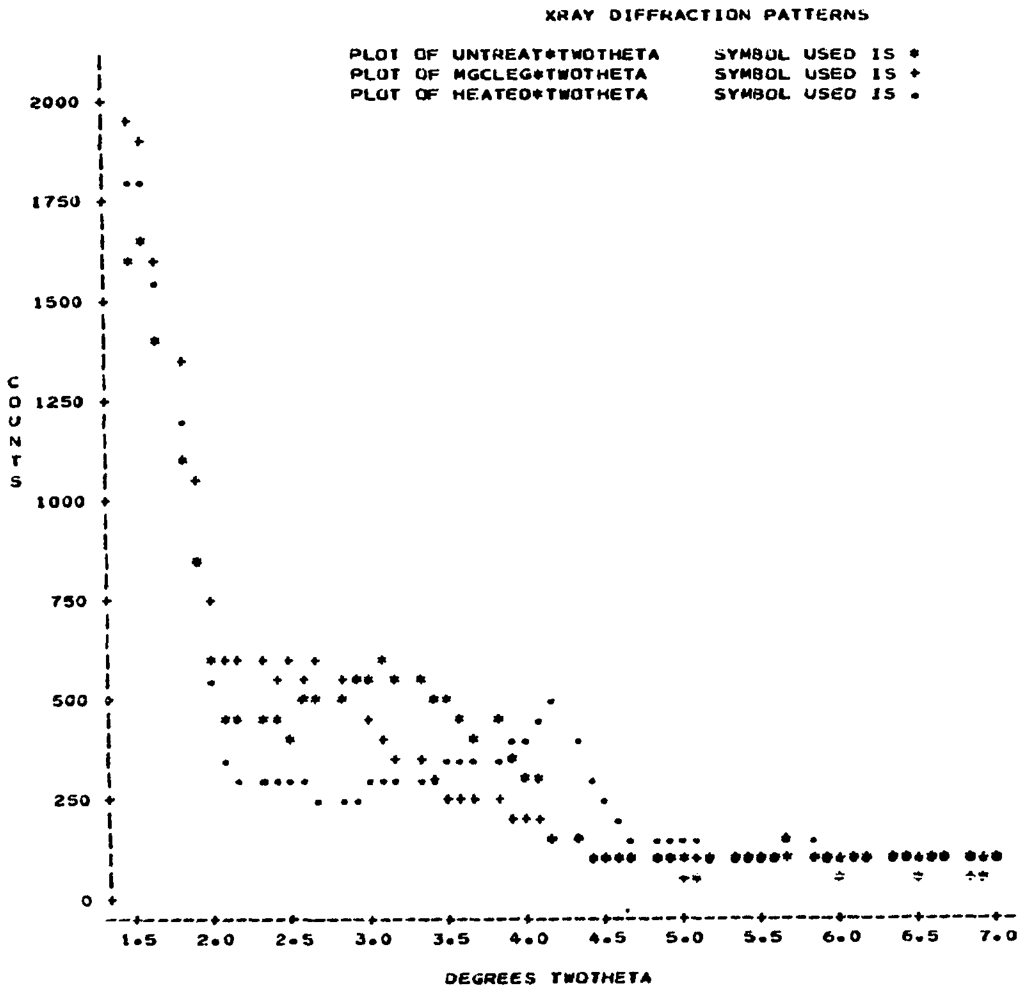

Figure 85. X-ray diffraction patterns for soil I2 (88-100 cm)

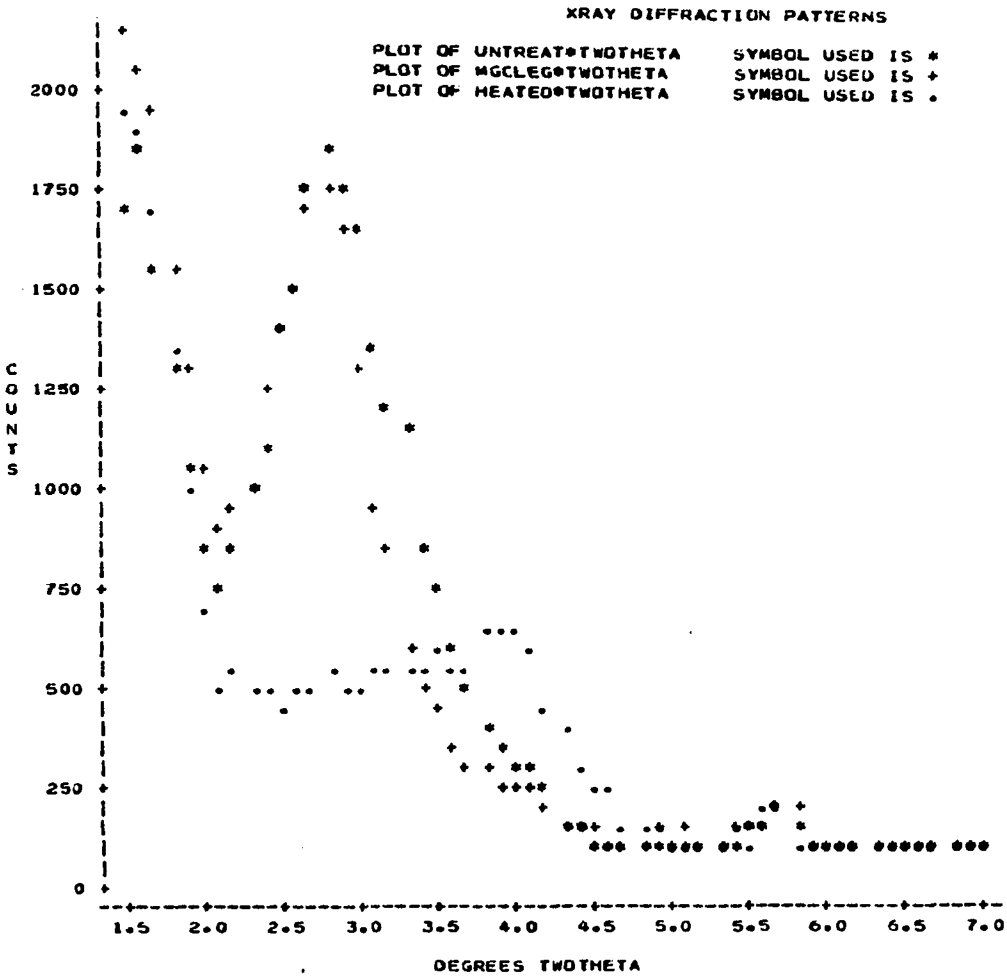

Figure 86. X-ray diffraction patterns for soil MINN2 (0-15 cm)

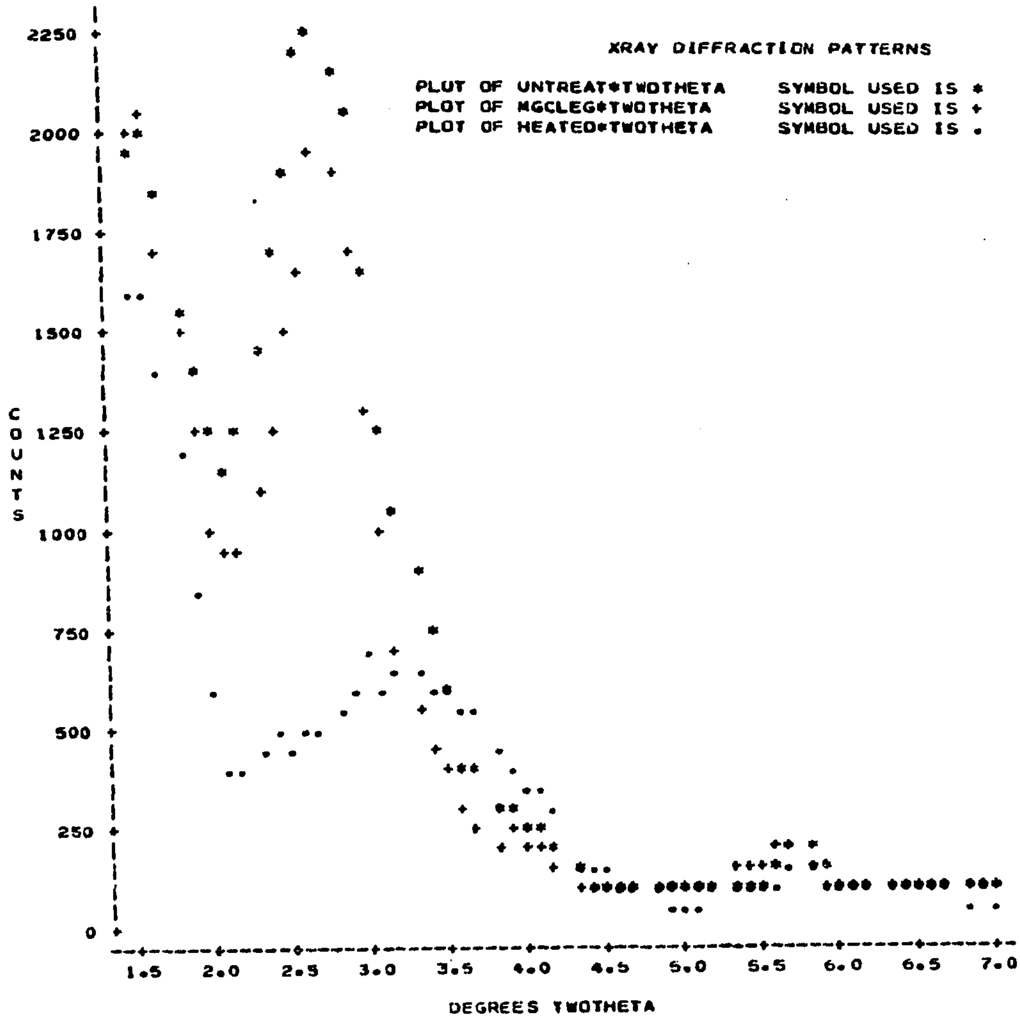

Figure 87. X-ray diffraction patterns for soil MINN2 (28-46 cm)

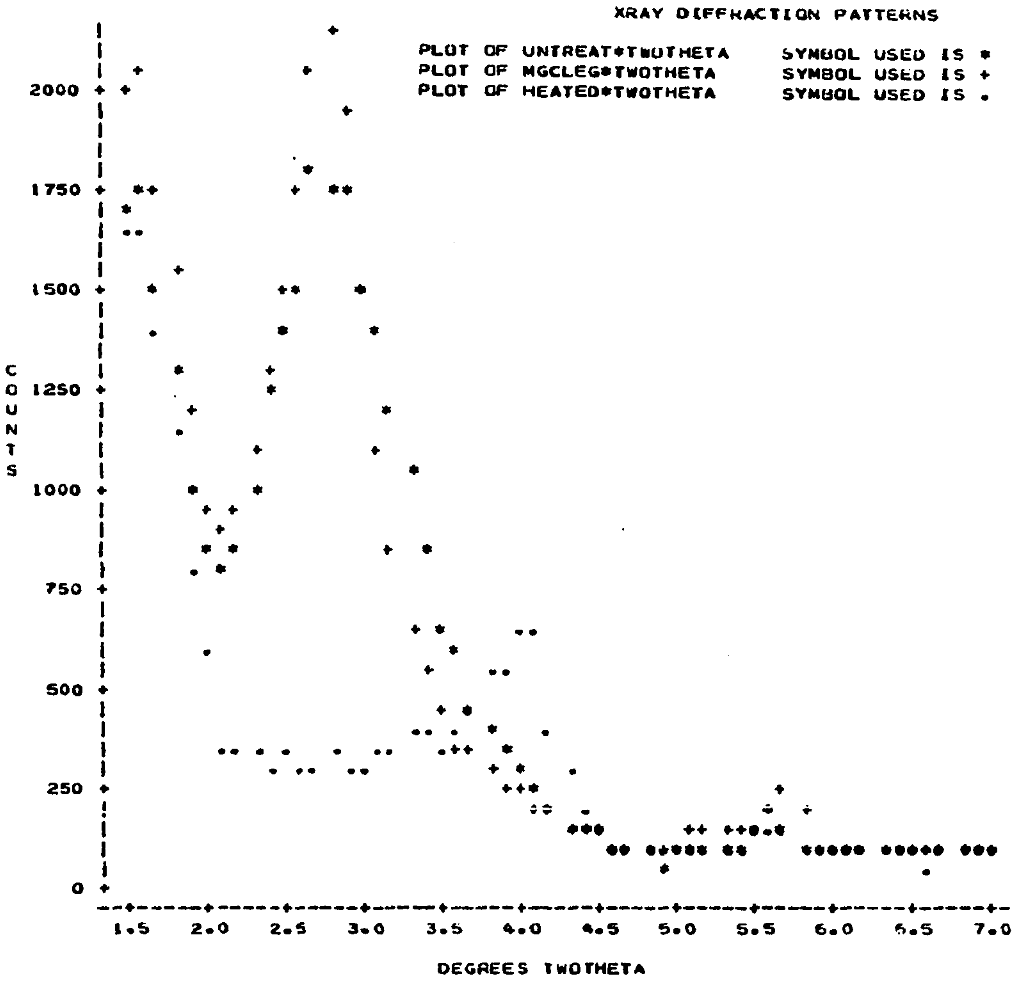

Figure 88. X-ray diffraction patterns for soil MINN2 (94-114 cm)

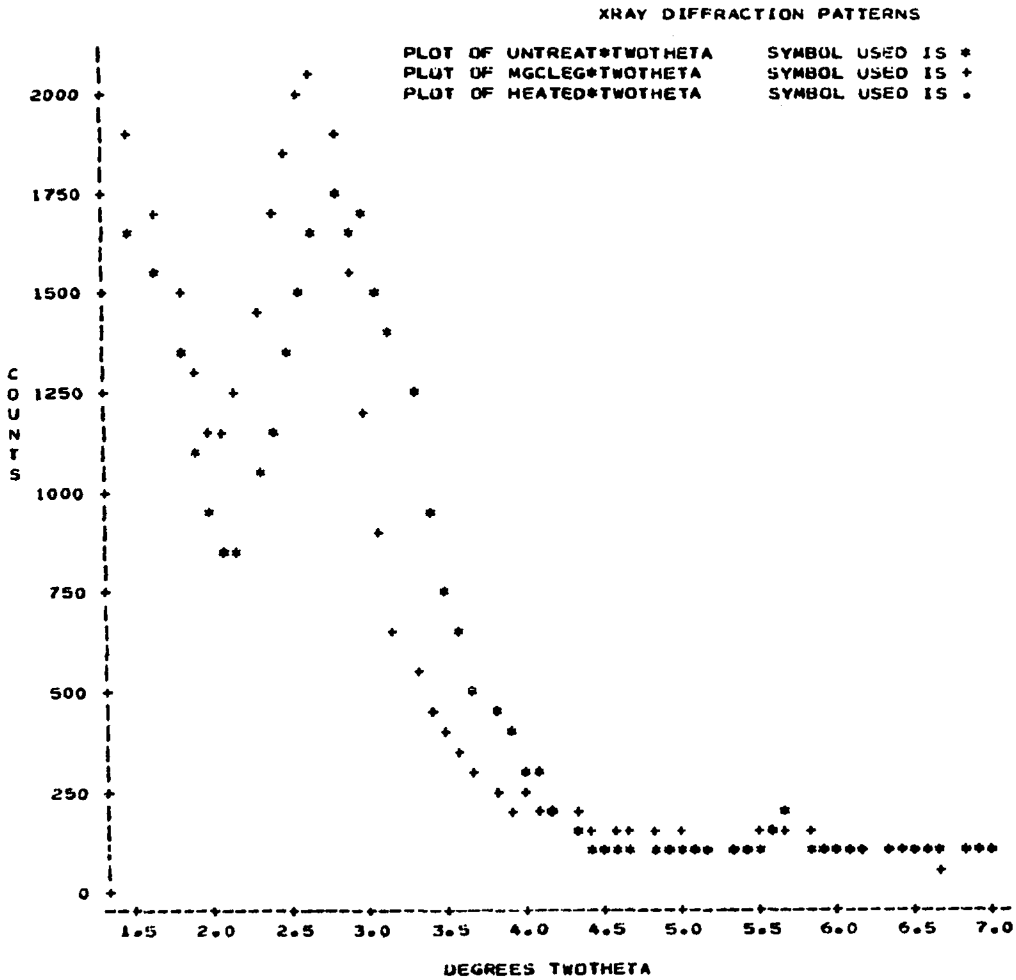

Figure 89. X-ray diffraction patterns for soil MINN2 (127-140 cm)

APPENDIX D: CHEMICAL, PHYSICAL, MINERALOGICAL, AND LANDSCAPE VARIABLES

<u>Chemical, physical, mineralogical, and landscape variables</u>:

The following is a list of the data used in the model equations involving chemical, physical, mineralogical, and landscape variables. The abbreviations TVEG, SL-ER, and PM have been coded as follows. The other variables have been identified in the text.

<u>Abbreviation</u>	<u>Identification code</u>
TVEG	Type of vegetation associated with VEG 0 = prairie 1 = transitional 2 = forested
SL-ER	Slope and erosion classes dominant in the area determined from soil survey map 10 = 0-2% 20 = 2-5% 30 = 5-9% 40 = 9-14% 1 = none to slightly eroded 2 = moderately eroded 3 = severely eroded EXAMPLE: 31, 5-9% slope, none to slightly eroded
PM	Dominant parent material of the upland soils 10 = loess 15 = loess-glacial till 20 = glacial till 30 = outwash 40 = bedrock 50 = lacustrine 0 = parent material noncalcareous 5 = parent material calcareous EXAMPLE: 155, loess-glacial till, calcareous

Soil	WGTCLAY	WGTTC	WGTAVP	WGTTP	WGTHION	WGTTK	INTERST	MONTMOR	K-CL
1	37.4	1.5	45	574	1.8×10^{-6}	-	-	-	-
16	25.1	1.4	7	329	4.0×10^{-7}	-	-	-	-
18	35.9	2.3	11	411	3.0×10^{-7}	-	-	-	-
21	31.8	1.5	4	504	1.0×10^{-7}	-	544	2596	316
22-1	32.2	2.1	11	521	5.0×10^{-7}	1.6	-	-	-
22-2	28.9	2.5	16	633	1.0×10^{-7}	-	-	-	-
24	36.4	1.9	19	495	7.9×10^{-7}	1.2	-	-	-
29	27.8	2.0	40	527	1.0×10^{-7}	1.6	-	-	-
31-1	27.7	1.5	20	683	2.4×10^{-8}	-	-	-	-
31-2	30.4	1.8	37	642	7.0×10^{-7}	1.4	1014	676	222
36	33.6	1.4	40	553	3.0×10^{-7}	1.8	1500	568	214
38	27.6	1.4	18	538	4.0×10^{-7}	-	-	-	-
4	28.6	1.4	7	246	1.3×10^{-6}	-	-	-	-
43	34.0	1.6	62	713	8.0×10^{-7}	1.4	-	-	-
44	36.7	1.8	47	709	3.0×10^{-7}	-	-	-	-
48	32.2	1.7	15	375	3.0×10^{-7}	-	-	-	-
5	31.8	1.0	39	513	1.0×10^{-6}	-	-	-	-
52	32.4	1.0	32	739	3.0×10^{-7}	1.6	-	-	-
54	32.5	1.3	8	388	2.0×10^{-7}	-	-	-	-
56	32.5	1.3	8	388	2.0×10^{-7}	-	799	664	188
6	33.6	1.8	15	651	8.0×10^{-7}	-	-	-	-
60	29.9	1.6	26	582	2.0×10^{-7}	1.1	340	0	92
62	30.6	1.9	11	386	1.4×10^{-6}	-	-	-	-
63	29.2	0.9	17	320	2.0×10^{-7}	1.4	-	-	-
71	34.3	1.5	8	385	7.2×10^{-8}	-	0	1409	398
73	34.3	1.7	26	504	3.0×10^{-7}	-	-	-	-
75	35.6	2.2	8	430	2.0×10^{-7}	-	-	-	-
79	29.5	1.7	4	289	4.0×10^{-7}	-	-	-	-
81	34.0	2.1	15	455	2.0×10^{-7}	-	-	-	-
86	31.2	1.5	35	532	9.0×10^{-7}	1.0	-	-	-
88	36.3	1.1	32	450	1.5×10^{-6}	1.5	-	-	-
95	31.5	2.3	24	709	4.5×10^{-8}	.9	1950	1230	456
96-1	29.0	3.2	5	730	7.0×10^{-8}	-	-	-	-
96-2	37.5	3.0	21	851	1.0×10^{-7}	-	-	-	-
97	34.8	2.0	35	674	2.9×10^{-6}	-	-	-	-
N1	34.4	1.7	7	484	9.7×10^{-8}	-	-	-	-
N2	30.5	1.4	45	707	2.0×10^{-6}	.8	0	3354	398
N3	36.8	1.2	39	565	2.6×10^{-7}	-	-	-	-
N4	28.9	1.2	56	527	1.0×10^{-6}	-	-	-	-
M1	27.5	1.2	19	382	3.0×10^{-7}	-	-	-	-
M2	34.6	1.1	24	526	1.6×10^{-6}	-	-	-	-
M3	33.4	1.0	35	470	7.0×10^{-7}	1.4	560	514	136
M4	35.3	1.3	4	288	1.2×10^{-7}	-	-	-	-
I	29.0	2.0	7	648	1.0×10^{-7}	-	-	-	-
I2	28.1	1.1	5	467	2.5×10^{-7}1	1.8	632	669	148
MINN1	47.8	2.0	17	581	1.0×10^{-7}	.9	-	-	-
MINN2	25.8	1.4	9	428	1.3×10^{-7}	-	2162	0	260

ILLITE	VEG	TVEG	SL-ER	PM	LONG	LAT	PPT	TEMP	WIDFLP	BUPSLI	STTOSI
-	150	1	42	150	94.45	41.15	81	9.5	760	390	110
-	390	1	31	105	91.00	41.45	89	9.5	300	100	100
-	5000	0	21	105	95.30	42.30	69	8.5	680	900	100
772	5000	0	11	305	95.15	43.00	71	8.0	800	100	100
-	125	1	32	105	91.15	43.00	84	8.5	200	125	100
-	180	1	42	105	91.15	43.00	84	8.5	250	100	100
-	5000	0	31	105	95.00	42.00	76	9.0	200	50	50
-	5000	0	11	100	91.30	41.00	89	10.5	150	25	75
-	190	2	42	105	91.00	42.30	87	9.0	400	200	150
356	1150	1	32	105	90.45	42.30	89	8.5	200	150	100
418	5000	0	43	105	95.30	40.45	84	11.0	1400	450	800
-	5000	0	32	105	92.45	42.30	84	8.5	300	125	100
-	150	1	42	150	93.00	40.15	87	10.5	400	300	300
-	5000	0	43	105	95.45	41.30	76	10.0	400	100	300
-	5000	0	31	100	91.30	41.00	89	10.5	250	100	75
-	150	1	42	205	92.00	41.30	89	9.5	150	76	50
-	5000	2	32	105	95.00	41.30	79	9.5	1160	730	150
-	170	1	20	105	91.30	41.30	87	10.0	150	75	25
-	300	1	42	150	92.30	41.30	87	10.0	450	300	50
346	150	1	32	100	91.30	40.15	89	11.0	150	125	50
-	1900	1	21	105	92.00	42.15	87	9.0	550	400	150
152	5000	0	20	305	96.15	43.30	64	8.0	1000	100	200
-	5000	0	30	100	92.30	41.15	87	10.5	250	75	100
-	230	2	42	150	93.14	41.30	84	10.0	400	100	200
460	5000	0	20	105	95.45	43.00	66	8.0	300	100	100
-	1700	1	42	155	95.00	40.45	87	10.0	1200	850	250
-	5000	0	32	105	96.00	42.45	66	8.5	450	100	100
-	900	2	42	155	92.30	41.30	87	9.5	200	150	100
-	966	1	42	105	92.30	42.00	87	9.0	425	100	100
-	760	1	42	150	94.00	41.00	84	10.0	1050	500	400
-	5000	0	21	105	95.15	32.30	74	8.5	1213	800	128
566	1850	1	21	505	93.30	43.15	79	8.0	800	1425	75
-	320	1	42	155	92.00	43.15	81	8.0	500	275	175
-	280	1	42	155	92.00	43.15	81	8.0	100	50	50
-	5000	0	32	105	96.00	42.30	69	9.0	1200	300	150
-	5000	0	42	105	97.00	42.15	61	9.0	703	128	384
970	5000	0	42	105	96.50	41.50	69	10.5	256	70	50
-	5000	0	32	105	96.00	43.00	64	11.0	580	325	260
-	5000	0	21	105	96.35	41.10	71	10.5	1970	150	830
-	256	1	41	200	93.50	40.20	86	11.5	2980	280	1130
-	5000	0	32	405	93.75	39.40	94	13.0	1080	566	240
192	900	2	42	200	93.45	39.00	86	11.5	2044	1098	610
-	305	2	42	200	92.05	40.20	94	11.5	2156	250	1580
-	100	2	42	305	89.30	40.05	89	11.5	500	700	200
272	5000	0	20	155	88.00	40.00	94	11.5	400	100	100
-	25	2	32	205	93.15	44.30	71	7.5	1000	500	400
264	-	-	-	-	93.40	44.00	71	7.0	-	-	-

APPENDIX E: SIMPLE CORRELATION COEFFICIENTS

Table 25. Simple correlation coefficients greater than ±.20 for laboratory analysis, Mo group (No. = number of samples)

Between variables		r	No.	Between variables		r	No.
Sand and	clay	-.24	10	TC and	AVP	.91	8
	TC	.75	8		TP	.78	8
	AVP	.65	10		IP	.44	8
	TP	.80	10		OP	.76	8
	IP	.74	10		OC/OP	.35	8
	OP	.44	10		OP/TP	.37	8
	OC/OP	-.25	8		HION	.88	8
	HION	.74	10		TK	.60	8
	STAVP	.64	10		STAVP	.94	8
	STAVK	.74	10		STAVK	.88	8
	STHION	.73	10		STHION	.88	8
	STBHION	.73	10		STBHION	.90	8
Silt and	clay	-.99	10	AVP and	TP	.78	10
	TC	-.65	8		IP	.32	10
	AVP	-.54	10		OP	.65	10
	TP	-.26	10		OC/OP	.27	8
	IP	.50	10		OP/TP	.26	10
	OP	-.62	10		HION	.98	10
	OC/OP	-.49	8		TK	.52	10
	OP/TP	-.74	10		STAVP	.93	10
	HION	-.42	10		STAVK	.98	10
	TK	-.85	10		STHION	.99	10
	STAVP	-.63	10		STBHION	.97	10
	STAVK	-.39	10				
	STHION	-.42	10	TP and	IP	.47	10
	STBHION	-.45	10		OP	.83	10
					OC/OP	-.24	8
Clay and	TC	.53	8		OP/TP	.22	10
	AVP	.44	10		HION	.85	10
	IP	-.59	10		TK	.37	10
	OP	.55	10		STAVP	.80	10
	OC/OP	.54	10		STAVK	.79	10
	OP/TP	.74	10		STHION	.85	10
	HION	.31	10		STBHION	.87	10
	TK	.84	10				
	STAVP	.53	10				
	STAVK	.28	10				
	STHION	.31	10				
	STBHION	.34	10				

Table 24. (Continued)

Between variables		r	No.	Between variables		r	No.
IP and	OP/TP	-.74	10	HION and	TK	.44	10
	HION	.42	10		STAVP	.92	10
	TK	-.52	10		STAVK	.99	10
	STAVK	.43	10		STHION	1.0	10
	STHION	.43	10		STBHION	1.0	10
	STBHION	.40	10				
				TK and	STAVP	.65	10
OP and	OC/OP	-.30	8		STAVK	.40	10
	OP/TP	.73	10		STHION	.43	10
	HION	.69	10		STBHION	.47	10
	TK	.75	10				
	STAVP	.81	10	STAVP and	STAVK	.91	10
	STAVK	.61	10		STHION	.91	10
	STHION	.68	10		STBHION	.93	10
	STBHION	.73	10				
				STAVK and	STHION	.99	10
OC/OP and	OP/TP	-.20	8		STBHION	.98	10
OP/TP and	HION	.21	10	STHION and	STBHION	1.0	10
	TK	.86	10				
	STAVP	.49	10				
	STBHION	.25	10				

Table 26. Simple correlation coefficients greater than ±.20 for laboratory analyses, GPS group (No. = number of samples)

Between variables		r	No.	Between variables		r	No.
Sand and	silt	-.95	44	TP and	IP	.54	63
	clay	-.81	44		OP	.75	63
	TC	-.37	33		OC/OP	.20	46
	IP	-.66	44		OP/TP	.22	63
	OP	-.29	44		HION	.45	63
	OP/TP	-.46	44		STHION	.31	46
	HION	-.28	44		STBHION	.38	46
Silt and	clay	.60	44	IP and	OC/OP	.26	46
	TC	.26	33		OP/TP	-.65	63
	IP	-.61	44		STAVK	.36	46
	OP	.22	44		STHION	.32	46
	OP/TP	.36	44		STBHION	.28	46
	HION	.24	44				
				OP and	OP/TP	.78	63
Clay and	TC	.44	33		HION	.58	63
	IP	-.57	44		STBHION	.21	46
	OP	.33	44				
	OC/OP	.21	33	OC/OP and	HION	.43	46
	OP/TP	.53	44		STAVK	.36	36
	HION	.28	44		STHION	.35	36
					STBHION	.35	46
TC and	AVP	.67	46				
	TP	.79	46	OP/TP and	HION	.45	63
	OP	.87	46		STAVK	-.30	46
	OC/OP	.51	46				
	OP/TP	.56	46	HION and	STHION	.36	46
	HION	.70	46		STBHION	.48	46
	STAVK	.24	36				
	STHION	.64	36	STAVP and	STAVK	.65	46
	STBHION	.61	36				
				STAVK and	STHION	.39	46
AVP and	TP	.47	62		STBHION	.52	46
	OP	.52	62				
	OC/OP	.43	46	STHION and	STBHION	.90	46
	OP/TP	.31	62				
	HION	.61	62				
	STAVP	.51	45				
	STAVK	26	45				

Table 27a. Simple correlation coefficients greater than ±.20 for laboratory analyses, MIH group (No. = number of samples

Between variables		r	No.
Sand and	silt	-.77	10
	clay	.27	10
	TC	.21	7
	AVP	.81	9
	TP	-.47	10
	IP	-.45	10
	HION	.54	10
	TK	-.82	4
	STAVP	.28	10
	STAVK	-.28	10
Silt and	clay	-.83	10
	TC	-.68	7
	AVP	.77	9
	IP	.46	10
	OP	-.39	9
	OC/OP	-.41	6
	OP/TP	-.43	9
	HION	-.48	10
	TK	.54	4
	STAVP	-.47	10
	STHION	-.25	10
Clay and	TC	.80	7
	AVP	-.25	9
	TP	.29	10
	IP	-.30	10
	OP	.54	9
	OC/OP	.61	6
	OP/TP	.49	9
	HION	.25	10
	TK	-.44	4
	STAVP	.47	10
	STHION	.31	10
	STBHION	.21	10
TC and	TP	.82	13
	OP	.56	12
	OC/OP	.40	12
	HION	.45	13
	STAVP	.55	13
	STHION	.24	13
AVP and	TP	.56	17
	IP	.66	17
	OP/TP	-.42	16
	HION	-.31	17
	TK	-.84	3
	STAVK	.31	17
TP and	IP	.52	18
	OP	.43	17
	OC/OP	.40	12
	STAVP	.29	18
	STBHION	.21	18
IP and	OP	-.49	17
	OC/OP	.84	12
	OP/TP	-.64	17
	HION	-.50	18
	TK	-.45	4
	STBHION	-.32	18
OP and	OC/OP	-.52	12
	OP/TP	.58	17
	HION	.59	17
	TK	-.91	3
	STAVP	.28	17
	STHION	.28	17
	STBHION	.61	17
OC/OP and	OP/TP	-.37	12
	HION	-.35	12
	STAVP	.59	12
	STBHION	-.27	12
OP/TP and	HION	.43	17
	TK	-.65	3
	STAVP	.27	17
	STHION	.29	17
	STBHION	.45	17
HION and	STAVP	.22	18
	STHION	.22	18
	STBHION	.44	18
TK	STAVK	.37	4
	STHION	.39	4
STAVP and	STAVK	.31	18
	STHION	.74	18
	STBHION	.49	18

Table 27b. Simple correlation coefficients greater than ±.20 for laboratory analyses, M group (No. = number of samples

Between variables		r	No.
Sand and	silt	-.47	18
	clay	-.55	18
	TC	-.45	14
	IP	.35	18
	OP	-.52	18
	OP/TP	-.54	18
	HION	.33	18
	TK	.82	6
	STAVP	-.42	8
	STAVK	-.38	8
	STHION	-.83	8
	STBHION	-.87	8
Silt and	TC	.50	14
	AVP	.24	17
	TP	.29	18
	OP	.31	18
	OC/OP	.23	14
	OP/TP	.26	18
	HION	-.21	18
	STHION	.33	8
	STBHION	.39	8
Clay and	TC	.39	14
	AVP	-.22	17
	OP	.25	18
	OC/OP	.24	14
	OP/TP	.20	18
	TK	-.77	6
	STAVP	.49	8
	STAVK	.47	8
	STHION	.80	8
	STBHION	.81	8
TC and	TP	.51	22
	OP	.67	22
	OC/OP	.59	22
	OP/TP	.45	22
	HION	.21	22
	TK	-.28	5
	STAVP	.65	10
	STAVK	.63	10
	STHION	.74	10
	STBHION	.72	10
AVP and	TP	.57	26
	IP	.60	26
	OC/OP	-.24	22
	OP/TP	-.29	26
	TK	.21	6
TP and	IP	.55	27
	OP	.36	27
	HION	.29	27
	STAVP	.71	12
	STAVK	.73	12
	STHION	.47	12
	STBHION	.43	12
IP and	OP	-.58	27
	OP/TP	-.86	27
	TK	.61	7
	STAVP	.27	12
	STAVK	.35	12

Table 27b. (Continued)

Between variables		r	No.	Between variables		r	No.
OP and	OP/TP	.90	27	HION and TK	TK	-.36	7
	TK	-.62	7		STAVP	.30	12
	STAVP	.73	12		STAVK	.24	12
	STAVK	.68	12		STHION	.33	12
	STHION	.79	12		STBHION	.21	12
	STBHION	.75	12				
				TK and	STAVP	-.30	3
OC/OP and	TK	-.37	5		STAVK	-.20	3
	STAVP	-.46	10		STHION	-.45	3
	STAVK	-.41	10		STBHION	-.55	3
	STHION	-.39	10				
	STBHION	-.42	10	STAVP and	STAVK	.99	12
					STHION	.74	12
OP/TP and	TK	-.78	7		STBHION	.79	12
	STAVP	.37	12				
	STAVK	.28	12	STAVK and	STHION	.69	13
	STHION	.63	12		STBHION	.75	12
	STBHION	.66	12				
				STHION and	STBHION	.95	12

Table 28. Simple correlation coefficients greater than ±.20 for laboratory analyses, SSM group (No. = number of samples)

Between variables		r	No.
Sand and	silt	-.82	23
	clay	.59	23
	TC	-.49	17
	AVP	.54	22
	OP	-.25	23
	OC/OP	-.57	17
	OP/TP	-.25	23
	HION	.56	23
	TK	-19	3
	STAVP	.21	22
	STHION	.50	22
Silt and	clay	-.94	23
	TC	.75	17
	AVP	-.46	22
	TP	.40	23
	OP	.51	23
	OC/OP	.39	17
	OP/TP	.43	23
	HION	-.44	23
	STAVK	.43	22
	STHION	-.35	22
	STBHION	.28	22
Clay and	AVP	.34	22
	TP	-.22	24
	OC/OP	-.21	17
TC and	AVP	.31	23
	TP	.64	24
	OP	.60	24
	OP/TP	.38	24
	HION	-.23	24
	STAVP	.46	24
	STAVK	.62	24
	STBHION	.45	24
AVP and	TP	.44	29
	OC/OP	-.39	23
	HION	.24	29
	TK	.57	3
	STAVP	.81	28
TP and	IP	.26	31
	OP	.57	31
	STAVP	.60	30
	STAVK	.50	30
	STBHION	.38	30
IP and	OP	-.52	31
	OC/OP	.56	23
	OP/TP	-m75	31
	HION	-.29	31
	TK	-.43	3
	STHION	-.46	30
	STBHION	-.47	30
OP and	OC/OP	-.21	23
	OP/TP	.89	31
	TK	.93	3
	STAVP	.35	30
	STAVK	.56	30
	STBHION	.64	30
OC/OP and	HION	-.55	23
	STAVP	-.37	23
	STHION	-.48	23
	STBHION	-.37	23
OP/TP and	STAVP	.41	30
	STHION	.32	30
	STBHION	.61	30
HION and	STAVP	.21	30
	STHION	.79	30
	STBHION	.46	30
STAVP and	STAVK	.51	30
	STBHION	.25	30
STAVK and	STBHION	.38	30
STHION and	STBHION	.70	30

Table 29. Simple correlation coefficients greater than ±.20 for laboratory analyses, CKL group (No. = number of samples

Between variables		r	No.	Between variables		r	No.
Sand and	silt	-.96	4	TC and	AVP	.66	9
	clay	-.99	4		TP	.83	9
	TC	.96	3		IP	.62	9
	AVP	.76	4		OP	.71	9
	TP	.60	4		OC/OP	.55	9
	IP	.20	4		OP/TP	.22	9
	OP	.75	4		HION	.69	9
	OC/OP	.33	3		STAVP	.77	9
	HION	1.0	4		STAVK	.80	9
	TK	-.27	3		STBHION	.64	9
	STAVP	.88	4				
	STAVK	.99	4	AVP and	TP	.87	12
	STHION	-.57	4		IP	.63	12
	STBHION	.25	4		OP	.47	12
					HION	.55	12
Silt and	clay	.92	4		TK	-.88	3
	TC	-.99	3		STAVP	.91	12
	AVP	-.56	4		STAVK	.75	12
	TP	-.41	4				
	OP	-.72	4	TP and	IP	.77	12
	OC/OP	-.48	3		OP	.47	12
	OP/TP	-.24	4		HION	.44	12
	HION	-.95	4		STAVP	.87	12
	STAVP	-.72	4		STAVK	.68	12
	STAVK	-.93	4				
	STHION	.40	4	IP and	OC/OP	.47	9
	STBHION	-.46	4		OP/TP	-.73	12
					STAVP	.51	12
Clay and	TC	-.94	3		STAVK	.25	12
	AVP	-.84	4				
	TP	-.69	4	OP and	OP/TP	.80	12
	IP	-.29	4		HION	.57	12
	OP	-.74	4		TK	-.35	3
	OC/OP	-.25	3		STAVP	.63	12
	HION	-.99	4		STAVK	.70	12
	TK	.42	3		STBHION	.25	12
	STAVP	-.94	4				
	STAVK	1.0	4				
	STHION	.65	4				

Table 29. (Continued)

Between variables		r	No.	Between variables		r	No.
OC/OP and	OP/TP	-.49	9	TK and	STAVP	-.74	3
	HION	.25	9		STAVK	-.39	3
	STBHION	.51	9		STHION	.82	3
					STBHION	.95	3
OP/TP and	HION	.30	12				
	STAVK	.28	12	STAVP and	STAVK	.92	12
					STHION	-.27	12
HION and	TK	-.31	3				
	STAVP	.74	12	STAVK and	STHION	-.24	12
	STAVK	.92	12		STBHION	.21	12
	STHION	-.31	12				
				STHION and	STBHION	.79	12

Table 30. Simple correlation coefficients greater than ±.20 for laboratory analyses, ASE group (No. = number of samples

Between variables		r	No.	Between variables		r	No.
Sand and	silt	-.65	10	TC and	AVP	.77	8
	clay	-.83	10		TP	.92	8
	TC	-.26	8		IP	.60	8
	IP	.70	10		OP	.95	8
	OP	-.51	10		OC/OP	.56	8
	OC/OP	-.57	8		OP/TP	.32	8
	OP/TP	-.90	10		HION	-.92	8
Silt and	TC	.63	8	AVP and	TP	.86	11
	AVP	.63	10		IP	.60	11
	TP	.40	10		OP	.49	11
	OP	.59	10		OC/OP	.50	8
	OC/OP	.64	8		HION	-.67	11
	HION	-.31	10				
				TP and	IP	.66	1
Clay and	TC	-.25	8		OP	.61	11
	AVP	-.51	10		OC/OP	.34	8
	TP	-.48	10		HION	-.93	11
	IP	-.90	10				
	OP	.24	10	IP and	OC/OP	.28	8
	OP/TP	.88	10		OP/TP	-.82	11
	HION	.31	10		HION	-.53	11
				OP and	OC/OP	.30	8
					OP/TP	.69	11
					HION	-.66	11
				OC/OP and	HION	-.29	8

Table 31. Simple correlation coefficients greater than ±.20 for laboratory analyses, OMT group (No. = number of samples

Between variables		r	No.	Between variables		r	No.
Sand and	silt	-.88	52	TP and	IP	.80	58
	clay	-.57	52		OP	.63	58
					OC/OP	.26	40
Silt and	OC/OP	.32	35		TK	-.50	3
					STAVP	-.33	28
Clay and	TC	-.32	35		STHION	.20	28
	OC/OP	-.30	35		STBHION	.28	28
	STAVP	-.28	25				
	STAVK	-.31	25	IP and OC	OC/OP	.26	40
	STHION	-.32	25		OP/TP	-.64	58
	STBHION	-.46	25		HION	-.42	58
TC and	AVP	.37	40	OP and	OP/TP	.65	58
	TP	.63	40		HION	.25	58
	IP	.24	40		STAVP	-.38	27
	OP	.81	40		STHION	.22	27
	OC/OP	.64	40		STBHION	.29	27
	OP/TP	.29	40				
	STAVK	.34	19	OC/OP and	STAVK	.40	19
	STHION	.45	19		STHION	.23	19
	STBHION	.31	19				
				OP/TP and	HION	.48	58
AVP and	TP	.82	59		STAVP	-.34	27
	IP	.79	58		STBHION	.25	27
	OP	.34	58				
	OC/OP	.25	40	HION and	STHION	-.27	28
	OP/TP	-.24	58				
	HION	-.45	59	STAVP and	STAVK	.77	28
	STHION	.34	28				
	STBHION	.26	28	STAVK and	STHION	.26	28
					STBHION	.22	28
				STHION and	STBHION	.76	28

Table 32. Simple correlation coefficients greater than ±.20 for laboratory analyses, GH group (No. = number of samples

Between variables		r	No.	Between variables		r	No.
Sand and	silt	-.34	5	TC and	AVP	.88	7
	clay	-.59	5		TP	.90	7
	TC	.42	3		IP	-.50	7
	TP	.25	5		OP	.96	7
	IP	-.55	5		OC/OP	.83	6
	OP	.61	5		OP/TP	.93	7
	OC/OP	.37	3				
	OP/TP	.72	5	AVP and	TP	.96	10
	HION	.40	5		OP	.79	10
	TK	.79	4		OC/OP	.54	6
	STHION	.23	5		OP/TP	.60	10
	STBHION	.45	5		HION	.33	10
					TK	.50	4
Silt and	clay	-.56	5		STHION	.60	10
	AVP	.55	5		STBHION	.79	10
	TP	.28	5				
	IP	-.25	5	TP and	OP	.84	10
	OP	.45	5		OC/OP	.57	6
	OP/TP	.40	5		OP/TP	.65	10
	HION	.69	5		HION	.26	10
	STAVP	.70	5		TK	.55	4
	STAVK	.77	5		STAVP	.92	10
	STHION	.73	5		STAVK	.88	10
	STBHION	.56	6		STHION	.63	10
					STBHION	.83	10
Clay and	TC	-.99	3				
	AVP	-.44	5	IP and	OP	-.57	10
	TP	-.47	5		OC/OP	-.31	6
	TP	-.47	5		OP/TP	-.77	10
	IP	.70	5		HION	-.26	10
	OP	-.92	5		STAVK	-.25	10
	OC/OP	-.98	3		STHION	-.50	10
	OP/TP	-.98	5		STBHION	-.52	10
	HION	-.94	5				
	TK	-.35	4	OP and	OC/OP	.63	6
	STAVP	-.56	4		OP/TP	.95	10
	STAVK	-.61	5		HION	.36	10
	STHION	-.83	5		TK	.55	4
	STBHION	-.88	5		STAVP	.84	10
					STAVK	.87	10
					STHION	.80	10
					STBHION	.96	10

Table 32. (Continued)

Between variables		r	No.	Between variables		r	No.
OC/OP and	OP/TP	.71	6	TK and	STAVP	.54	4
	HION	.53	6		STAVK	.55	4
	STAVP	.52	6		STHION	.52	4
	STAVK	.49	6		STBHION	.56	4
	STHION	.24	6				
	STBHION	.49	6	STAVP and	STAVK	.98	10
					STHION	.73	10
OP/TP and	HION	.39	10		STBHION	.88	10
	TK	.34	4				
	STAVP	.67	10	STAVK and	STHION	.75	10
	STAVK	.73	10		STBHION	.89	10
	STHION	.73	10				
	STBHION	.87	10	STHION and	STBHION	.92	10
HION and	TK	.26	4				
	STAVP	.27	10				
	STAVK	.31	10				

Table 33. Simple correlation coefficients greater than $\pm.20$ for laboratory analyses, TM group (No. = number of samples)

Between variables		r	No.	Between variables		r	No.
Sand and	silt	-.53	25	AVP and	TP	.68	25
	clay	-.29	25		IP	.80	25
	TC	-.43	21		OP/TP	-.43	24
	AVP	.37	24		HION	-.49	25
	TP	.31	25		TK	.33	8
	IP	.70	25		STAVP	.61	19
	OP	.70	25		STAVK	-.24	19
	OC/OP	-.25	19		STHION	-.51	19
	OC/TP	-.72	24		STBHION	-.59	19
	HION	-.51	25				
	STAVP	.47	19	TP and	IP	.63	26
	STAVK	-.37	19		OP	.40	26
	STHION	-.41	19		OC/OP	-.38	20
	STBHION	-.42	19		HION	-.38	20
					TK	.47	8
Silt and	clay	-.66	25		STAVP	.70	20
	AVP	-.40	24		STHION	-.68	20
	TP	-.46	25		STBHION	-.39	20
	HION	.25	25				
	TK	.32	8	IP and	OP	-.46	26
	STAVK	.47	19		OP/TP	-.79	25
	STHION	.45	19		HION	-.54	25
	STBHION	.43	19		STAVP	.72	20
					STAVK	-.25	20
TC and	AVP	-.33	22		STHION	-.53	20
	TP	.25	22		STBHION	-.53	20
	IP	-.38	22				
	OP	.57	22	OP and	OC/OP	-.44	20
	OC/OP	.37	20		OP/TP	.85	25
	OP/TP	.58	21		HION	.23	26
	HION	.54	22		TK	.32	8
	STAVK	.37	17		STAVK	.43	20
	STHION	.25	17		STBHION	.22	20
	STBHION	.58	17				
				OC/OP and	OP/TP	-.36	20
					HION	.39	20
					TK	-.86	5
					STAVK	-.27	15
					STHION	.35	15

Table 33. (Continued)

Between variables		r	No.	Between variables		r	No.
OP/TP and	HION	.48	35	TK and	STAVP	.25	8
	STAVP	-.49	19		STAVK	.48	8
	STAVK	.38	19		STHION	-.26	8
	STHION	.30	19				
	STBHION	.48	19	STAVP and	STAVK	.22	20
					STHION	-.64	20
HION and	TK	-.36	8		STBHION	-.52	20
	STAVP	-.66	20				
	STHION	.78	20	STAVK and	STBHION	.38	20
	STBHION	.87	20				
				STHION and	STBHION	.81	20

Table 34. Simple correlation coefficients greater than ±.20 for laboratory analyses, DT group (No. = number of samples

Between variables		r	No.	Between variables		r	No.
Sand and	silt	-.92	18	AVP and	TP	.72	18
	clay	-.67	18		OP	.44	18
	TC	-.21	16		HION	-.30	18
	TP	-.34	18		STAVP	.99	9
	OP	-.43	18		STHION	.46	9
	OC/OP	-.30	16		STBHION	.37	9
	OP/TP	-.56	16				
	HION	-.41	18	TP and	IP	.37	18
	STAVP	-.78	9		OP	.47	18
	STAVK	-.72	9		STAVP	.75	9
					STAVK	.70	9
Silt and	clay	.32	18		STHION	.25	9
	AVP	.24	18		STBHION	.31	9
	TP	.50	18				
	OP	.31	18	IP and	OP	-.64	18
	OC/OP	-.24	16		OP/TP	-.84	16
	OP/TP	.43	16		HION	-.59	18
	HION	.24	18		STHION	-.59	9
	STAVP	.82	9		STBHION	-.59	9
	STAVK	.75	9				
				OP and	OC/OP	-.26	16
Clay and	TC	.37	16		OP/TP	.91	16
	IP	-.57	18		HION	.59	18
	OP	.43	18		STAVP	.64	9
	OP/TP	.60	16		STAVK	.65	9
	HION	.52	18		STHION	.90	9
	STAVP	-.67	9		STBHION	.95	9
	STAVK	-.61	9				
				OC/OP and	OP/TP	-.25	14
TC and	TP	.36	16				
	IP	-.57	16	OP/TP and	HION	.67	16
	OP	.89	16		STAVK	.22	8
	OP/TP	.75	14		STHION	.78	8
	HION	.66	16		STBHION	.82	8
	STAVP	.39	9				
	STAVK	.39	9	STAVP and	STAVK	.98	9
	STHION	.68	9		STHION	.57	9
	STBHION	.88	9		STBHION	.43	9
				STAVK and	STHION	.65	9
					STBHION	.44	9
				STHION and	STBHION	.87	9

Table 35. Simple correlation coefficients greater than ±.20 for laboratory analyses, D group (No. = number of samples

Between variables		r	No.
Sand and	silt	-.53	14
	TC	-.77	9
	AVP	-.22	14
	IP	.54	14
	OP	-.27	14
	OP/TP	-.23	14
	HION	-.25	14
	STAVP	-.41	5
	STAVK	-.59	5
	STHION	-.83	5
	STBHION	-.71	5
Silt and	clay	-.87	14
	TC	.74	9
	AVP	.22	14
	OP	-.21	14
	OC/OP	.34	9
	OP/TP	.43	14
	HION	-.34	14
	TK	.78	4
	STAVP	.99	5
	STAVK	.98	5
	STHION	.83	5
	STBHION	.91	5
Clay and	TC	-.31	9
	IP	-.35	14
	OP	.39	14
	OP/TP	.63	14
	HION	.58	14
	TK	-.85	4
	STAVP	-.61	5
	STAVK	-.44	5
	STBHION	-.26	5
TC and	AVP	.42	18
	TP	.75	18
	OP	.95	18
	OP/TP	.79	18
	HION	.33	18
	TK	.37	7
	STAVP	.64	8
	STAVK	.82	8
	STHION	.77	8
	STBHION	.82	8
AVP and	TP	..48	27
	OP	.40	27
	OP/TP	.25	27
	TK	.74	8
	STAVP	.81	13
	STAVK	.84	13
	STHION	.56	13
	STBHION	.57	13
TP and	IP	.33	27
	OP	.75	27
	OP/TP	.52	27
	TK	.58	8
	STAVP	.72	13
	STAVK	.74	13
	STHION	.51	13
	STBHION	.47	13
IP and	OP	-.36	27
	OC/OP	.58	18
	OP/TP	-.59	27
	HION	-.51	27
	TK	.66	8
	STAVP	.28	13
	STHION	-.46	13
	STBHION	-.41	13
OP and	OC/OP	-.33	18
	OP/TP	.94	27
	HION	.46	27
	STAVP	.42	13
	STAVK	.75	13
	STHION	.84	13
	STBHION	.86	13

Table 35. (Continued)

Between variables		r	No.	Between variables		r	No.
OC/OP and	OP/TP	-.50	18	STAVP and	STAVK	.88	13
	STAVP	.48	8		STBHION	.23	13
	STAVK	.42	8				
				STAVK and	STHION	.58	13
OP/TP and	HION	.58	27		STBHION	.61	13
	STAVK	.53	13				
				STHION and	STBHION	.99	13
HION and	STAVK	.51	13				
	STHION	.96	13				
	STBHION	.96	13				
TK and	STAVP	.71	8				
	STAVK	.60	8				

Table 36. Simple correlation coefficients greater than ±.20 for laboratory analyses, FDS group (No. = number of samples)

Between variables		r	No.	Between variables		r	No.
Sand and	silt	.23	5	AVP and	TP	.54	12
	clay	-.59	5		IP	.56	12
	TC	-.74	3		OP	.49	12
	AVP	-.44	5		OC/OP	.67	9
	TP	-.76	5		OP/TP	.36	12
	OP	-.83	5		HION	.66	12
	OC/OP	-.40	3				
	OP/TP	-.81	5	TP and	IP	.76	12
	HION	-.66	5		OP	.96	12
					OC/OP	.64	9
Silt and	clay	-.92	5		OP/TP	.92	12
	TC	.85	3		HION	.77	12
	AVP	.32	5				
	TP	-.29	5	IP and	OP	.58	12
	IP	.32	5		OC/OP	.64	9
	OP	-.47	5		OC/TP	.46	12
	OC/OP	.99	3		HION	.50	12
	OP/TP	-.63	3				
				OP and	OC/OP	.59	9
Clay and	TC	-.21	3		OP/TP	.97	12
	TP	.54	5		HION	.83	12
	OP	.73	5				
	OC/OP	.59	3	OC/OP and	OP/TP	.49	9
	OP/TP	.85	5		HION	.60	9
	HION	.32	5				
				OP/TP and	HION	.70	12
TC and	AVP	.66	9				
	TP	.92	9				
	IP	.76	9				
	OP	.90	9				
	OC/OP	.87	9				
	OP/TP	.84	9				
	HION	.77	9				

Table 37. Simple correlation coefficients greater than $\pm.20$ for laboratory analyses, F group (No. = number of samples

Between variables		r	No.
Sand and	silt	-.87	35
	clay	.41	35
	TC	.29	33
	AVP	-.35	35
	TP	.20	22
	OC/OP	-.38	20
	HION	-.34	35
	TK	-.72	4
	STAVK	-.63	8
	STHION	-.69	8
	STBHION	-.73	8
Silt and	clay	-.81	35
	TC	-.33	33
	AVP	.31	35
	TP	-.39	22
	OP	-.23	22
	OC/OP	.36	20
	HION	.31	35
	TK	.86	4
	STAVP	.22	8
	STAVK	.59	8
	STHION	.67	8
	STBHION	.70	8
Clay and	TC	.32	33
	TP	.49	22
	OP	.36	22
	OC/OP	-.31	20
	STAVP	-.22	8
	STAVK	-.48	8
	STHION	-.56	8
	STBHION	-.57	8
TC and	AVP	-.54	46
	TP	.77	33
	IP	-.52	33
	OP	.86	33
	OC/OP	-.63	33
	OP/TP	.86	33
	HION	.29	46
	TK	.95	4
	STAVP	.41	20
	STAVK	.43	20
	STHION	.35	20
	STBHION	.43	20
AVP and	TP	-.27	38
	IP	.71	38
	OP	-.64	38
	OC/OP	.67	33
	OP/TP	-.78	38
	HION	.48	51
	TK	1.0	4
	STAVK	-.50	24
	STHION	-.56	24
	STBHION	-.65	24
TP and	OP	.80	38
	OC/OP	-.69	33
	OP/TP	.59	38
	STAVK	.25	24
	STHION	.23	24
IP and	OP	-.60	38
	OC/OP	.62	33
	OP/TP	-.78	38
	STHION	-.24	24
	STBHION	-.34	24
OP and	OC/OP	-.86	33
	OP/TP	.94	38
	STAVK	.36	24
	STHION	.39	24
	STBHION	.41	24

Table 37. (Continued)

Between variables		r	No.	Between variables		r	No.
OC/OP and	OP/TP	-.85	33	STAVP and	STAVK	.65	24
	STAVP	.59	20		STHION	.64	24
					STBHION	.51	24
OP/TP and	STAVK	.31	24				
	STHION	.38	24	STAVK and	STHION	.98	24
	STBHION	.45	24		STBHION	.95	24
HION and	TK	.99	4	STHION and	STBHION	.97	24
	STAVK	-.35	24				
	STHION	-.39	24				
	STBHION	-.45	24				

Table 38. Simple correlation coefficients greater than $\pm.20$ for laboratory analyses, NE group (No. = number of samples

Between variables		r	No.	Between variables		r	No.
Sand and	silt	.30	24	AVP and	TP	.53	40
	clay	-.77	24		IP	.69	40
	OC/OP	.37	19		OP	-.21	40
	HION	.20	24		OC/OP	.24	32
	TK	-.30	4		OP/TP	-.48	40
	STAVP	-.42	4		HION	.54	40
	STAVK	-.48	4		TK	-.74	4
	STHION	-.40	4		STAVK	.22	10
	STBHION	.23	4		STBHION	.22	10
Silt and	clay	-.84	24	TP and	IP	.73	40
	TC	-.38	19		OP	.38	40
	AVP	.47	24		HION	.65	40
	TP	.22	24		STAVP	-.85	40
	IP	.36	24		STAVK	.41	10
	OP/TP	.35	24		STHION	.94	10
	HION	.42	24		STBHION	.91	10
	STAVP	.73	4				
	STAVK	-.76	4	IP and	OP	-.35	40
	STHION	-.88	4		OC/OP	.30	32
	STBHION	-.96	4		OP/TP	-.67	40
					HION	.49	40
Clay and	TC	.27	19		TK	-.52	4
	AVP	-.36	24		STAVP	-.63	10
	IP	-.32	24		STHION	.88	10
	OP/TP	.30	24		STBHION	.79	10
	HION	-.40	24				
	TK	.73	4	OP and	OC/OP	-.50	32
	STAVP	-.42	4		OP/TP	.90	40
	STAVK	.92	4		HION	.24	40
	STHION	.60	4		TK	.98	4
	STBHION	.76	4		STAVP	-.68	10
					STHION	.88	10
TC and	TP	.30	32		STBHION	.79	10
	IP	-.24	32				
	OP	.79	32				
	OP/TP	.61	32				
	TK	.61	4				
	STAVP	-.73	8				
	STHION	.78	8				
	STBHION	.53	8				

Table 38. (Continued)

Between variables		r	No.	Between variables		r	No.
OC/OP and	OP/TP	-.52	32	STAVP and	STAVK	-.25	10
	TK	-.47	4		STHION	-.83	10
	STAVP	-.55	8		STBHION	-.86	10
	STHION	.40	8				
	STBHION	.24	8	STAVK and	STBHION	.32	10
OP/TP and	STAVP	-.23	10	STHION and	STBHION	.89	10
	STHION	.51	10				
	STBHION	.39	10				
HION and	TK	.57	4				
	STAVP	-.80	10				
	STHION	.85	10				
	STBHION	.96	10				

Table 39. Simple correlation coefficients greater than ±.20 for laboratory analyses, MISSO group (No. = number of samples)

Between variables		r	No.
Sand and	silt	-.88	42
	clay	-.68	42
	TP	-.30	42
	OP	-.34	42
	OP/TP	-.24	42
	HION	-.47	42
	STAVP	.31	20
	STHION	-.59	20
	STBHION	-.55	20
Silt and	clay	.24	42
	TC	.38	31
	AVP	.21	40
	TP	.34	42
	OP	.33	42
	OC/OP	.31	31
	OP/TP	.21	42
	HION	.24	42
	TK	-.61	4
	STAVP	-.20	20
	STHION	.38	20
	STBHION	.39	20
Clay and	HION	.59	42
	TK	.63	4
	STAVP	-.39	20
	STAVK	-.20	20
	STHION	.75	20
	STBHION	.64	20
TC and	TP	.40	31
	IP	.28	31
	OP	.30	31
	OC/OP	.72	31
	HION	-.30	31
	STAVP	.44	16
	STAVK	.56	16
AVP and	TP	.64	40
	IP	.85	40
	OP/TP	-.51	40
	STAVP	.36	20
	STAVK	.48	20
TP and	IP	.77	42
	OP	.72	42
	HION	.22	42
	TK	-.79	4
	STAVK	.23	20
	STHION	.49	20
	STBHION	.59	20
IP and	OP/TP	-.64	42
	STAVP	.25	20
	STAVK	.45	20
OP and	OC/OP	-.38	31
	OP/TP	.65	42
	HION	.40	42
	STAVP	-.25	20
	STHION	.69	20
	STBHION	.69	20
OC/OP	HION	-.36	31
	STAVP	.72	16
	STAVK	.73	16
	STHION	-.36	16
OP/TP	HION	-.36	42
	STAVP	.72	20
	STAVK	.73	20
	STHION	-.36	20
HION and	TK	-.24	4
	STAVP	-.47	20
	STAVK	-.22	20
	STHION	.61	20
	STBHION	.55	20
STAVP and	STAVK	.88	20
	STHION	-.47	20
	STBHION	-.30	20
STAVK and	STHION	-.33	20
STHION and	STBHION	.81	20

Table 40. Simple correlation coefficients greater than $\pm.20$ for laboratory analyses, ILL group (No. = number of samples

Between variables		r	No.	Between variables		r	No.
Sand and	silt	-.96	15	TC and	AVP	.64	14
	clay	-.63	15		TP	.82	14
	TC	-.54	15		IP	.93	12
	AVP	-.72	15		OP	.56	12
	TP	-.20	15		OC/OP	.57	12
	IP	-.37	13		OP/TP	-.70	12
	OC/OP	-.37	13		HION	-.34	14
	OP/TP	.40	13		STAVP	.76	7
	HION	-.33	15		STAVK	.68	7
	STAVP	-.80	8		STHION	-.29	7
	STAVK	-.80	8		STBHION	-.73	7
	STHION	.25	8				
	STBHION	.63	8	AVP and	TP	.35	15
					IP	.57	13
Silt and	clay	.39	15		OC/OP	.66	12
	TC	.43	14		OP/TP	-.59	12
	AVP	.75	15		OP/TP	-.59	12
	IP	.29	13		STAVP	.60	8
	OC/OP	.64	12		STAVK	.60	8
	OP/TP	-.37	13		STBHION	-.55	8
	HION	.48	15				
	STAVP	.80	8	TP and	IP	.85	13
	STAVK	.79	8		OP	.88	13
	STHION	-.21	8		OP/TP	-.43	13
	STBHION	-.60	8		STHION	-.69	8
					STBHION	-.53	8
Clay and	TC	.60	14				
	AVP	.31	15	IP and	OP	.50	13
	TP	.53	15		OC/OP	.57	12
	IP	.49	13		OP/TP	-.83	13
	OP	.29	13		HION	-.27	13
	OC/OP	.24	12		STAVP	.56	6
	OP/TP	-.32	13		STAVK	.43	6
	HION	-.26	15		STHION	-.96	9
	STAVP	.39	8		STBHION	-.62	6
	STAVK	.42	8				
	STHION	-.28	8				
	STBHION	-.44	8				

Table 40. (Continued)

Between variables		r	No.	Between variables		r	No.
OP and	OC/OP	-.34	12	OP/TP and	STAVP	-.75	6
	HION	-.46	13		STAVK	-.70	6
	STAVP	-.41	6		STHION	.65	6
	STAVK	-.51	6		STBHION	.32	6
	STHION	-.34	6				
	STBHION	-.35	6	HION and	STAVP	.69	8
					STAVK	.68	8
OC/OP and	OP/TP	-.85	12		STHION	-.25	8
	STAVP	.88	5				
	STAVK	.89	5	STAVP and	STAVK	.98	8
	STHION	-.32	5		STHION	-.24	8
					STBHION	-.32	8

Table 41. Simple correlation coefficients greater than ±.20 for laboratory analyses, MINN group (No. = number of samples

Between variables		r	No.	Between variables		r	No.
Sand and	clay	-.78	15		TK	.43	3
	TC	-.42	15		STAVP	-.22	14
	AVP	-.38	15		STAVK	-.34	14
	TP	-.56	15				
	IP	-.51	15	TP and	IP	.74	16
	OP	-.20	15		OP	.56	16
	OP/TP	.29	15		OC/OP	-.57	16
	HION	.37	15		STAVP	.30	14
	TK	.93	3		STAVK	.36	14
	STAVP	-.36	13		STHION	-.56	14
	STHION	.24	13		STBHION	-.34	14
Silt and	clay	-.53	15	IP and	OC/OP	-.29	16
	TC	-.38	15		OP/TP	-.75	16
	AVP	-.27	15		STAVP	.55	14
	TP	.22	15		STAVK	.52	14
	IP	.39	15		STHION	-.75	14
	OC/OP	-.53	15		STBHION	-.36	14
	OP/TP	-.32	15				
	HION	-.29	15	OP and	OC/OP	-.48	16
	TK	-.47	3		OP/TP	.64	15
	STAVP	.73	13		TK	-.44	3
	STAVK	.88	13				
	STHION	-.62	13	OC/OP and	TK	-.48	3
					STAVP	-.64	14
Clay and	TC	.61	15		STAVK	-.54	14
	AVP	.49	15		STHION	.48	14
	TP	.33	15		STBHION	.46	14
	OP	.27	15				
	OC/OP	.24	15	OP/TP and	HION	.22	16
	STAVK	-.52	13		TK	-.92	3
					STAVP	-.43	14
TC and	AVP	.28	16		STAVK	-.39	14
	OP	.41	16		STHION	.48	14
	OC/OP	.47	16				
	TK	-.72	3	HION and	TK	.83	3
	STAVP	-.55	14		STHION	.55	14
	STAVK	-.41	14		STBHION	.43	14
	STHION	.29	14				
	STBHION	.44	14	STAVP and	STHION	-.49	14
					STBHION	-.37	14
AVP and	TP	.54	16				
	IP	.41	16	STAVK and	STHION	-.50	14
	OP	.28	16	STHION and	STBHION	.70	14